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THE COCO-NUT LEAF-MINER

Promecotheca papuana, *Csiki* (*antiqua*, Wse.)*

J.G.

(*John L. Froggatt, B.Sc., Entomologist.*)

Marked infestation by *P. papuana* sporadically occurs in various parts of the Territory, but it is usually worst in those parts where no definite dry period occurs throughout the year. Its attacks are not confined to palms of any particular age, occurring from the young plant with one or more expanded leaves to a palm 80 feet or more in height.

Infestation usually begins along the sea frontage, and, if not checked, later spreads inwards. In the early stages, the attack is confined to a limited number of palms, and may be localized in one or more groups of palms. Under normal conditions, the pest is held in control by *Microhymenopterous* parasites of the eggs and larvae.

At the end of 1937, this pest appeared along that portion of the North Coast-road from Rabaul, where coco-nut palms and all other vegetation had suffered severely from the effects of the deposition of pumice dust resulting from the eruptions in Blanche Bay in May of that year. In the early stages of infestation the attack was limited to a comparatively narrow strip along the foreshore, but measures recommended were not adopted by the owners of plantations and groves within the area, and the infestation rapidly developed into severe plague form within the limits of a strip for the most part not more than a quarter of a mile wide from the sea. Small localized infestations occurred later at several sites along the roads leading from the North Coast towards Kokopo, and investigation showed that these were places where natives, carrying produce to and from native markets within this area, were accustomed to stop either to rest or for making a centre for sale. The produce was carried in baskets made from plaited coco-nut foliage, and examination of these baskets proved that many of them carried either *Promecotheca* egg masses or larvae; baskets on being emptied were thrown away into the undergrowth, and, in many cases, the adult beetles had bred out and attacked coco-nut palms in the immediate vicinity. Outside the main infested area a slight attack of the pest was seen, but natural parasites quickly stopped any serious development; within the severely infested area parasites gradually bred up naturally, and were assisted by liberation of adults bred in the laboratory, Rabaul, and, finally, by May, 1938, had the plague under control.

A short account of the life history of the pest and of the *Microhymenopterous* parasite indigenous to New Britain are here given, with directions for control.

The Adult Beetle.

The adult beetles are slightly less than 1 cm. in length (.8–.9 cm.), and about .4–.5 cm. in width; the antennae are dark, the head and thorax iridescent dark blue; slightly more than half of the anterior portion of the elytra (wing covers) is yellow to orange in colour and the remainder dark metallic blue. Colour variations occur in some parts of the Territory, the metallic blue markings being much reduced in extent and intensity, and the orange to almost a yellow-brown.

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* *Vide Entomological Bulletin* No. 1, T.N.G., —*New Guinea Agricultural Gazette*, Vol. 2, No. 1., 1936.

At first, the beetles feed only on the younger foliage, and on the under-surface of the leaflets in lines running parallel with the veins in the leaf. The edges of these feeding areas shrivel and tend to contract the surrounding tissues, causing the leaflets to curl. Where the number of beetles is small, the amount of damage so caused is relatively slight, but as the numbers increase with the development of succeeding generations, the damage caused by the adults alone is considerable. As the female beetles become gravid and are ready to deposit eggs, a migration gradually takes place onto the older foliage, where feeding will then also take place.

Normally, the adults cling firmly to the under-surface of the foliage, but may be disturbed by high winds, or by persons approaching close to young palms. The beetles will then drop downwards from the leaf and then fly upwards, but they are not strong fliers and do not travel far on the wing.

Adults kept under observation in the insectaries on growing palms have lived for more than six weeks, but it is possible that this period may be longer under field conditions. Deposition of eggs under insectary conditions in Rabaul continued for nearly the whole life of the female and occurred in from four to six days after emergence from the mine.

After emerging from the pupae, the adults remain in the mine until the body has hardened up and then cut their way through the upper surface of the leaf, generally not eating a hole but cutting sufficient to form a flap.

The Eggs.

The eggs are laid flat on the under-surface of the leaflets, and covered with fine portions of undigested leaf tissue set together by a mucous secretion from the female. From one to four eggs may occur in mass, but two or three are the more common. The egg mass on the leaf presents a dome-shaped structure with the long axis of the mass slightly more than 3 mm. in length and the shorter width of about 2.5 mm.

The eggs are laid side by side, and measure slightly over 1.5 mm. (average 1.7 mm.) in length. The period from deposition of eggs to emergence of larvae has been from 11 to 17 days (average 12 days) in Rabaul, and 13 to 16 days in Manus.

The Larva.

On emergence, the larva breaks the surface of the leaf and commences to feed on the green tissue in between the two surfaces, which are thus caused to separate and form a "blister". The leaf tissue so affected dies and turns brown. A single mine may extend the whole length of a leaflet, but is often very much shorter, depending largely on the number of larvae present. They feed straight ahead, the excreta being cast behind, but on such occasions as may arise where the mine comes against another older one, the larvae may turn and continue in another direction in fresh tissue; also, when they come to the tip of a leaflet, they may return through the mine and start out afresh from the other end or from some place on the side; such cases mostly occur when the infestation has developed into plague proportions.

The adult larvae are dull, creamy white in colour with a brown head-capsule, and measure slightly more than 1 cm. in length (average 1.2 cm.). There are three larval instars, which may be readily distinguished by the size of the head capsule, the average of a series of measurements being—

1st instar ..	.5421 mm.
2nd „ ..	.7276 mm.
3rd „ ..	1.0519 mm.

The larvae prior to moulting on the completion of each instar (stage of growth when the old skin is shed), and also before pupation, retreat from the head of the mine into the old channelling for two to three days. This habit often causes the death of many of the first instar larvae in particular, due to the drying of the tissues at the head of the mine forming a barrier that the newly-moulted larva cannot penetrate.

This dry band persits in the mines, even after the next stage larva passes on, as a faint dark line, and forms one means of determining what stage of development the larvae have reached in any mine. An examination of the cast head capsules in a mine also determines the stage of development of the larva.

The number of larvae present in a mine varies from one to four, a series of counts giving the following percentages:—

1 larva per mine ..	14.7
2 larvae „ ..	45.9
3 „ „ ..	33.9
4 „ „ ..	5.5

Under insectary conditions in Rabaul, the larval stage varied from 17 to 23 days (average 18 days). In Manus this period has varied from 17 to 29 days.

The Pupa.

The pupa is light brown in colour, and measures slightly less than 1 cm. in length (.8 cm. average), and externally exhibits the structure of the adult, tightly compacted together. It is capable of a certain amount of movement within the mine, which is especially noticed if the walls of the mine are touched in the immediate vicinity of the pupa.

Under insectary conditions in Rabaul, the pupal period varied from 12 to 24 days (average 21 days). In Manus, this has varied from 15 to 16½ days.

Life Cycle.

From the figures obtained by breeding the beetles in insectaries in Rabaul, it has been found that the life cycle (the period from deposition of egg to emergence of adult) varies from 44 to 52 days, with an average of 48 days. In Manus, the life cycle has varied from 48 days to 60 days (average 55 days).

Control.

In order to control the pest before material damage is caused, it is essential that measures be undertaken as soon as the pest is first noticed. The pest population is then small and limited in spread, so that the extent of the work that has to be done is so much less than is the case once the pest has started to spread from the original centre of infestation.

There are three lines of attack that may be adopted, either singly or in conjunction with one another—mechanical measures, the use of insecticides as either spray or dust, and biological measures.

MECHANICAL MEASURES.

Wherever *Promecotheca* appears in numbers beyond normal for the locality, and while natural enemies, wasp parasites, are in insufficient numbers to hold the pest in check, cutting off and burning infested fronds, combined with collecting and destroying all the adult beetles possible, will check an infestation satisfactorily. This work must, however, be carried out thoroughly and extensively over the affected area. Such measures were carried out with success over a very large extent of coco-nut lands in the Philippines in 1930-31, and have also proved successful on more than one occasion in this Territory in the initial stages of an outbreak. If the fronds are cut carefully, the greater majority of the beetles will come to the ground on the fronds and can there be readily collected and destroyed.

In such cases as those in which flares on poles can be handled with reasonable ease, scorching of the undersurface of the fronds will kill large numbers of the beetles, and destroy larvae in the mines. Comparatively tall palms have been treated in this way by fastening half a dry coco-nut husk to the end of a long bamboo to the top end of which two long ropes were tied; one native held the base of the pole, and two others held the ropes at different points out from the base of the pole and drew the flare along the fronds and around the palm.

In areas where palms are sufficiently small to be reached from the ground or from low stages, the egg masses can be rubbed off the leaves, the adults collected, and the larvae crushed by drawing the mines through between the thumb and fingers; this would obviate the removal of the foliage.

In all cases where the parasites are found to be multiplying, any measures that lead to the destruction of the mines will kill large numbers of the wasps, and hinder the rate of natural control of the pest.

Any source from which the pest may travel into cultivated areas should be searched for and, when found, should be thoroughly treated.

A method that can be used with advantage to destroy numbers of the adult beetles where plentiful, is to cut fresh young fronds of any palms that may be attractive to the adults (e.g., "sak-sak," *Metroxylon sagu*, or "nipa" palms, *Nipa fruticans*), and standing these upright in the ground in rows between the palms; the beetles come to rest on the fronds, on which they can be destroyed by spraying with strong soap solution, or other contact insecticide, or by hand collection.

USE OF INSECTICIDES.

Stomach poisons (such as lead or calcium arsenate), or contact insecticides (such as soap solution, lime sulphur fluid, or nicotine sulphate), can be applied as sprays or dusts, where power spraying or dusting machinery is available and, with the former, where sufficient supplies of soft water are readily obtainable. Nicotine sulphate (i.e., "Blackleaf 40") can be mixed with the arsenicals to make a combined stomach poison and contact mixture. It must be remembered that the action of a contact insecticide is relatively transitory, although the action may be fairly rapid, but the arsenicals remain on the foliage for an appreciable time after application.

For spraying, arsenate of lead is mixed at the rate of 1 lb. of the powder, or 1½ lb. of the paste form, to 50 gallons of water. Unless a "sticker" is already mixed with the powder, it is advisable to add some preparation that will assist in making the poison spread out on and adhere to the foliage; calcium caseinate is a general-purpose preparation that can be used for this purpose with safety.

Nicotine sulphate is obtainable as a standard preparation under the name of "Blackleaf 40", and is generally used at a rate of 1 part to 800 parts of water.

Using dry dusts, derris preparations can be used in addition to arsenicals, and, in tests carried out, it has been found that 10 per cent. arsenate of lead, using fine ground lime as a filler, and a preparation containing 1 per cent. "cube" content, killed 90 per cent. of the beetles treated within two days, and calcium arsenate killed 60 per cent. in the same time. Arsenate of lead and the derris preparation, combined in one dust, killed the same percentage as either alone.

Arsenate of lead sprayed on to foliage killed over 95 per cent., and the foliage so treated remained toxic for at least a week, even after being exposed to rain. Both nicotine sulphate and lime sulphur fluid killed the adult beetles quickly, but the foliage did not remain toxic for more than a few hours after application.

BIOLOGICAL CONTROL.

The value of parasitic insects in the control of scale insects has been known for many years, but their use for the control of beetle pests is only of recent date.

During the course of observations on coco-nut pests in 1930, a small *Hymenopterous* parasite of the larvae of *Promecotheca* was found at two centres on the south coast of New Britain, and, later, the same parasite was collected at other centres on New Britain. At none of these places was there more than a trace of the pest, and the number collected was very small. Specimens sent to the Imperial Institute of Entomology, London, were determined as belonging to the family *Eurytomidae,* genus *Eurytoma.* The number of specimens available were insufficient to enable a specific identification to be made, but a larger series has since been despatched for this purpose. From information on hand, it is evident that this is the natural control of *Promecotheca papuana* in New Britain.

In the early stages of the *Promecotheca* outbreak on the North Coast-road, Rabaul, in 1937, this parasite was found in small numbers over the greater part of the infested area, but was definitely numerous outside that area. On the northern side of the infestation nearer to Rabaul, these wasps were more numerous than elsewhere within the affected sector. In those parts where the parasites were plentiful, the number of mines was so small that the possibilities of distribution of the wasps from these centres were strictly limited. In March, 1938, it was evident that the parasite had increased very considerably, and the effect of its work became marked over a large section of the area by early April.

With the supply of material available, breeding of the parasites was taken up in the laboratory in Rabaul, partly to study the life history and habits, and partly to breed up for liberation in the field. The wasp bred readily in captivity, especially in 2nd and 3rd instar larvae. The mines carrying the larvae were placed in glass tubes with parasites, which were fed on slightly-diluted honey, or sugar syrup; exposure of the mines to the parasites was maintained for three to four days, when the mines were placed in new tubes, and the parasites transferred on to new mines.

The adults of *Eurytoma* sp. are small metallic black wasps with an iridescent green sheen on the body: the joints and tarsi of the legs are whitish. The female measures up to 3.7 mm. (.15 of an inch) in length, with the male rather smaller (2.8 mm. = .1 of an inch). The antennae of the two sexes are quite distinct, and form a ready means of identification for separating the sexes in arranging the proportions in the breeding tubes.

The female wasp punctures the upper surface of the *Promecotheca* mine with the lancet-like ovipositor and deposits the eggs on the outside of the host larva. The parasite grubs, on emerging, attach themselves to the body of the *Promecotheca* grub and suck the body substance until only the mere skin remains. When the host larva is attacked, it retreats from the head of the mine, and becomes dormant, and exhibits little, if any, movement when disturbed.

The wasp larvae are elongated whitish bodies about 3 mm. in length when full grown; there are usually 4 to 5 per host larva, but there are often more. Pupation usually takes place on the site of feeding, each pupa being attached separately to the wall of the mine by the anal end of the body. The pupae are jet black in colour and are about the same size as the adults.

On emergence from the pupa, the adults remain for a short time within the mine, and then eat a small circular (emergence) hole through the leaf tissue, usually on the upper surface, although some emerge through the lower surface, immediately over the site of pupation. There may be any number of emergence holes from one to seven, but usually there are two to four per mine. As many as 25 adults have been bred from a single mine, but the number will obviously vary according to the number of *Promecotheca* larvae present.

The life-cycle has varied from 15 to 19 days (average 17 days) in the laboratory in Rabaul; the adults have lived for six to seven weeks, males usually dying before the females. Strong colonies have been bred, using female wasps six weeks old.

Eurytoma sp. is apparently only a larval parasite, more readily developing in the second and third instar larvae. Pupae placed in the tubes with the live parasites matured into adult beetles, although in a few mines dead pupae of *Promecotheca* have been found which appeared normal, but may have been attacked by wasp larvae which, although unable to penetrate the pupal integument, yet caused the death of the pupa.

OTHER PARASITES RECORDED FROM THE TERRITORY.

In the Rabaul-Kokopo and Gasmata areas other species of small wasp has been bred from *Promecotheca* larvae; the species has been identified as belonging to the family *Eulophidae, Closterocerus splendens,* Kovv.; this species has also been bred from *Promecotheca* larvae in Manus.

In the Manus district, two other larval, and one egg, *Hymenopterous* parasites have been bred from *Promecotheca* mines and egg-masses collected in the field. Both the larval parasites belong to the family *Eulophidae*, one a *Derostenus* sp., and the other *Entedon* sp.; the egg parasite has been identified as *Anastatus* sp.) (family *Eupelmidae*); *C. splendens* has also been bred from *Promecotheca* eggs collected on New Britain.

Small ants have been found destroying *Promecotheca* egg masses.

The "Kurukum" ant, *Oecophylla smaragdina virescens,* F., has often been stated to destroy *Promecotheca,* but our observations do not support this statement. Plantations and groves badly attacked by *Promecotheca* have been examined in which this ant was in swarms, not only in the heads of the palms, but on other vegetation amongst the palms. An experiment was carried out in the Talasea district, where an island on which *Promecotheca* infestation was present was selected, and these ants introduced from other parts, and left untouched for several weeks; the infestation at the end of the period had increased to severe proportions in the interim.

The Pentatomid *Amyotea reciprocus* Walk has been found attacking *Promecotheca* adults; this predator is, however, relatively scarce.

PROMECOTHECA PARASITES IN OTHER COUNTRIES.

Taylor records two parasites of *Promecotheca reichei* Baly in Fiji—*Oligosita utiles* Kaw. of the eggs, and *Elasmus hispidarum* Ferr. of the larvae—and also a mite, *Pediculoides ventricosus* Newp. All the parasites referred to, except the mite *P. ventricosus,* are minute wasps.

The mite attacks the parasites as well as the *Promecotheca* larvae, and negatives the value of the wasp parasite to such an extent that Taylor was sent to Java to study any *Promecotheca* parasites in that country. Three primary parasites of *Promecotheca nuciferae* Maulik. were found,* of which *Pleurotropis*

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* *Biological Control of an Insect Pest,* T. H. C. Taylor, 1937.

parvulus Ferr., a larval and pupal parasite, was successfully introduced into Fiji in 1933. This species was also introduced into the New Hebrides at the end of 1937 from Java by Dupertuis.

Larval parasites of *Promecotheca cumingi* Baly have been recorded from the Philippine Islands.

INTRODUCTION OF P. PARVULUS INTO THE TERRITORY OF NEW GUINEA.

In 1936, the possibilities of introducing this parasite into this Territory from Fiji were investigated, but a combination of circumstances then prevented it being carried out.

Early in 1938, a colony of *Promecotheca* larvae, parasitized by *P. parvulus*. was sent from the New Hebrides through the courtesy of M. Dupertuis, but owing to extended delays in transit they were all dead on arrival. Later in the same year, through the assistance of W. R. Carpenter & Co. Ltd., and of the Department of Agriculture, Suva, another colony of adult *P. parvulus* was introduced from Fiji, by steamer to Sydney and thence by aeroplane to Rabaul, but these died *en route*. Finally, another colony from Fiji arrived alive on 6th September, 1938, partly as adults and partly as pupae in parasitized adult larvae of *Promecotheca*. This package was despatched in ship's cooler from Fiji to Sydney, where, on the ship's arrival, W. R. Carpenter & Co. Ltd. kept the parasites packed in ice, and, without delay, freighted them by mail 'plane to Rabaul.

The introduction of these parasites over so great a distance without personal and daily attention was due to a set of exceptionally favorable circumstances, that are rarely to be met with, owing to the synchronizing of steamer arrival and 'plane departure from Sydney. Any further period of cold storage in transit would almost certainly have been fatal to the parasites.

The adult parasites received were set on larvae of *Promecotheca papuana* the same day as received, and breeding work continued until all the parasites died. The first generation was not as large as was hoped for, possibly due to the effect of the long transit in cold storage. The second generation was, however, highly satisfactory, and liberations in the field were commenced within eight weeks of the receipt of the original colony.

A few notes are given on the life history, habits, &c., of this parasite, ascertained during the breeding work in developing the colony for acclimatization and distribution.

The adult females are about one-twentieth to one-twenty-fifth of an inch in length, with the males smaller; the former lived for a period up to 21 days, and the latter a few days less.

The adults are very active, the females being strongly attracted to light; they have fed freely on slightly diluted honey.

The life cycle occupied from 17 to 23 days, with an average of 19½ days.

The highest number of parasites from a mine containing three *Promecotheca* larvae was 39 in the first generation, and from a four-larvae mine 79 in the second generation.

FUMIGATION AND FUMIGANTS.

(*John L. Froggatt, B.Sc., Entomologist.*)

Insect pests infesting many forms of agricultural products, as well as orchard trees and nursery stocks, can be most effectively treated by the process of fumigation.

This is essentially a combined chemical and entomological matter; the chemical side comprising the study of gases for the dilution or saturation of the atmosphere surrounding the objects to be treated, which will be poisonous to the pests and non-poisonous to the materials on which the pests may be feeding. The entomological side of the work is to study the reaction of insects and plants to the different vapours and gases used, and determine the limits of susceptibility to each poison used of both pests and hosts.

As the chemical used, known as the fumigant, is a poisonous vapour or gas, it is essential that the greatest care be taken to render the enclosure inside which fumigation is to be carried out perfectly gastight. All cracks, holes and other openings must be closely sealed as the first step in the proceedings; pasting strips of brown paper over all such is generally sufficient, unless they are large. Lack of attention to such matters will easily lead to failure in results, and may even lead to the death of animals, or humans, in the vicinity of any leaks.

Provision for efficient ventilation after the process is completed is also essential before starting operations, in the case where buildings are to be treated. Furthermore, the work must be arranged to allow a margin of safety to enable the operator to leave the enclosure before the fumes become sufficient to catch him.

As the quantity of the fumigant, called the "dosage", depends on the cubic capacity of the enclosed space in which the operations are to be carried out, this must first be accurately determined.

Where live plants are not to be treated, the exposure to the gas should be from eight to twelve hours; with plants, the exposure is somewhat shorter.

Fumigation of orchard trees is carried out under specially prepared tents, and, where limited quantities of grain are to be treated, proofed tarpaulins can often be used. In all such cases, the bottom of the canvas must be covered over in such a way as to prevent escape of the fumigant.

Fumigation chambers for general purposes are made of concrete faced with bitumen, and provided with air-inlet valves at the bottom, and an air-exhausting plant at the top. Doors must be made so as to be gas-tight, as also must all air inlet and outlet openings.

When rice, wheat and other cereals and seeds are fumigated, they should be stored after treatment in insect-proof containers, otherwise re-infestation may result. Combining fumigation and storage of maize, &c., large galvanized iron tanks, with a pipe at the bottom which can be closed, are in common use in many countries. The fumigant can be introduced at the top and, after the required period for exposure, the pipe at the bottom is opened, and the fumigant vapours allowed to drain off, after which the openings at top and bottom are closed. Grain can be readily removed as required, and the remainder remains safe from re-infection.

Bulk storage is best maintained in concrete silos, arrangements for fumigation being made outside, and the grain, after treatment, being conveyed direct into the silo.

The choice of chemicals for commercial fumigation is rather limited, the main ones comprising—

Hydrocyanic acid (prussic acid).
Carbon disulphide.
Paradichlorbenzene.
Ethylene oxide.
Sulphur.
Nicotine.
Carbon tetrachloride.
Chloropocrin.

HYDROCYANIC ACID GAS.

This is by far the most commonly-used fumigant, and is applicable to practically all fumigation purposes.

The gas is colourless and very slightly lighter than air; it has an odour resembling that of bitter almonds. It diffuses rapidly and, being lighter than air, this is mostly upwards. Under normal conditions, it will not penetrate readily through tightly packed materials, such as sacks of grain and flour. By partially exhausting the air from the chamber, this difficulty is largely eliminated.

The gas is one of the most deadly known poisons, very rapidly killing animals, and also plants when the dosage is too great or the exposure too prolonged.

Hydrocyanic acid gas can be generated in several ways.

1. *From Calcium Cyanide.*—This chemical is obtainable as a powder, in granules and in flakes, and in varying strengths; no acid is required for the generation of the gas, this taking place on exposure to the air, the rate of evolution being dependent on the humidity.

It is eminently suitable for the fumigation of buildings, plants, rodent burrows, and for the treatment of certain types of sap-sucking insects.

In the treatment of orchard trees, the trees are covered with tents and the powder blown in under force, thus eliminating all the trouble with containers, acid, &c., required by the "pot method", referred to later.

For buildings, &c., 1 lb. per 1,000 cubic feet of air space (where the strong grade is used) is sufficient for all ordinary purposes; about double this dosage is required with the weaker grade.

In the United States of America, for the treatment of grain in bulk storage. the chemical is run in with the grain in the chutes.

For the destruction of soil-frequenting pests, and rodents, the chemical is blown into the channels and burrows, and the openings plugged. Ant nests can be cleared out in a similar manner.

2. *From Liquified Hydrocyanic Acid.*—This is supplied in steel cylinders, and is freed by opening a valve at the top of the cylinder, the gas being led into the enclosure by pipes from the valve.

One pound of the liquid is sufficient to fumigate 3,000 cubic feet of air space in buildings, &c.

3. *By the Pot Method.*—In this, the gas is generated by mixing sodium or potassium cyanide in earthenware containers with sulphuric acid and water; specially enamelled iron basins can also be used as containers.

The proportions per 1,000 cubic feet of air space of the chemicals are—

Water	30 fluid ounces
Sulphuric acid (commercial)	15 fluid ounces
Sodium cyanide (pure)	10 ounces

The acid and water are *slowly* mixed togeher, otherwise splashing may occur, and the sodium cyanide dropped in. It is often advisable to place the weighed quantity of the cyanide in a thin paper bag, as the action of the acid on the cyanide is thereby delayed slightly, thus giving a greater margin of safety to the operator.

4. A special chamber or machine is in use in some parts in which the above chemicals are mixed, and the gas led into the fumigation chamber by pipes connected with the generator.

The use of calcium cyanide and liquified hydrocyanic acid are gradually replacing the older methods with the use of acid and potassium or sodium cyanide.

Another form in which this fumigant is available is felted-paper discs impregnated with the fumigant, and which on exposure to the air yield the poison gas. The dosage is varied according to the number of discs used.

CARBON DISULPHIDE, CS_2.

In its commercial form, carbon disulphide is an almost colourless liquid with a strong and disagreeable smell. It rapidly volatilizes into a gas on exposure which, mixed with air, forms an explosively inflammable mixture. Great care has, therefore, to be exercised in using it, the glowing end of a cigarette or the glowing bowl of a pipe, or even a spark from two metal pieces striking together, being sufficient to ignite the vapours.

The gas is two and a half times heavier than air, and, therefore, sinks to the bottom of any container in which it is used; it has great penetrating power through tightly-packed materials. Any container in which it is used, therefore, must be thoroughly gas-tight.

This chemical cannot be used for the fumigation of living plants, owing to its high toxicity towards all forms of plant life and, even in small quantities, it will cause giddiness and nausea in humans.

It is well suited for the treatment of grain, and can also be used for the destruction of ant-nests; for the latter, a small quantity is poured into one or more holes in the nest, which is then covered with wet sacks; after five minutes, one of the bags can be lifted and a flare thrown on to the nest, which is shattered by the ensuing explosion.

The usual dosage for the treatment of grain is 4 to 5 pounds per 1,000 cubic feet of air space in the chamber, allowing 24 hours exposure. The temperature plays an important part in successful fumigation with this chemical, and should not be below 70 degrees Fahrenheit.

Owing to the vapours being so much heavier than air, the liquid should be placed in the top of the container either in a shallow basin, or poured on to sacks: by the latter method, a more rapid diffusion takes place,

PARADICHLORBENZENE $C_6H_4Cl_2$.

This chemical is available in a white crystalline form, and volatilizes readily on exposure to air; the vapours are about one and a quarter times heavier than air, and are non-inflammable.

It is used against certain root-boring and soil-frequenting insects, and for keeping seeds free from insect pests in storage; it cannot be used with grain that is for consumption by either humans or animals, as it leaves a very strong taint. Cases are on record where grain so treated, and fed to fowls, brought about a taint in the eggs, and, when such grain was fed to dairy cows, a taint came out in the milk.

It is excellent for the destruction of "white ants" (termites) in houses or timber when introduced into the channelling. It will penetrate further when dissolved in kerosene at the rate of 1 lb. to 4 gallons, and the solution poured in. It can also be used for the protection of furs and woollens in tightly closed containers.

The writer has used this chemical with very successful results against the "tobacco beetle", *Lasioderma serricorne* Fabr., infesting bindings of large ledgers, &c., treatment being carried out in a tightly-closed concrete chamber.

ETHYLENE OXIDE $(CH_2)_2O$.

This chemical is a liquid with a boiling point of 14 degrees Centigrade (57 degrees Fahrenheit), and is used extensively at the Port of London for the fumigation of dried fruits, &c., steel barges with gas-proof covers being used for the purpose.

In application, about 10 per cent. of carbon dioxide is added to the fumigant in steel cylinders to provide a greater pressure for expulsion of the ethylene oxide.

Supplementary to this treatment, the warehouses where the cases are stored are sprayed with a solution of pyrethrins in a highly-refined non-volatile oil of the nature of medical paraffin.

SULPHUR DIOXIDE SO_2

This gas is used to a certain extent in insect fumigation, but it is generally not as effective as those referred to previously.

The gas is generated by burning sulphur at the rate of from 2 to 6 lb. per 1,000 cubic feet of air space, the amount depending on the insects to be killed and the material to be treated. In the presence of moisture, sulphur dioxide is a strong bleaching agent.

It is slightly heavier than air, and is not applicable in many cases, as it destroys the viability of the seed of most grain crops, and, also, has a deleterious effect on the baking quality of flour.

The action of burning sulphur in an air-tight container is partly due to suffocation, owing to the removal of the oxygen to form sulphur dioxide, and, also, in part due to the formation of a poisonous gas.

NICOTINE.

This alkaloid is used extensively in the fumigation of greenhouses, but has little, if any, application in this Territory.

CARBON TETRACHLORIDE.

This chemical is a heavy liquid, yielding a gas about one and a half times heavier than air, but it is not nearly as toxic to most insects as carbon disulphide, requiring four to five times the dosage for an equivalent result. It has the advantage of being non-inflammable.

CHLOROPICRIN.

The vapour of this chemical is very heavy, but has a low volatility, and is non-inflammable. It corrodes metals, and has an irritating effect on the person using it, causing the eyes to water freely.

The power of penetration of the gas is particularly good, but is markedly affected by temperature.

It is more toxic to insects than carbon disulphide, but the susceptibility of insects to the vapour shows marked variation. It is less toxic to humans than to insects and rodents, but cannot be used for the fumigation of plants.

Owing to the heavy nature of the vapour, this chemical is very suitable for the fumigation of rodent burrows, and it has been used for the destruction of insects (moths, &c.) in upholstered furniture.

Chloropicrin has been used in grain stores and flour mills for killing moths, &c., but some experiments have shown that it has a definite effect on the gluten content, which, however, disappears when the material treated is exposed for several days to the open air.

"WHITE ANT" FUMIGATION.

A special technique has been developed in Malaya for the fumigation of "white ants" (termites) in living trees. This consists of burning arsenic and sulphur together in a special combustion chamber and blowing the fumes into the channels of the termites through a pipe leading from the combustion chamber.

The highly-poisonous fumes are thus deposited in the interior of the nest inside the trunk of the tree, and results in killing out the pest, without in any way damaging the tree.

RAINFALL MEMORANDA.

Inches of rainfall × 2,323,200 = cubic feet per square mile.
" " " × 14½ = millions of gallons per square mile.
" " " × 3,630 = cube feet per acre.

NEW CEYLON INDUSTRY.*

Ceylon is to try to develop an export trade in brown paper made from coco-nut husks. Good white paper, it has been found, can also be made out of husks, but its manufacture is not economical. The bleaching of the husk fibres for this purpose raises the production cost excessively. But brown paper can be made at an economical cost.

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* From Supplement to the *British Trade Journal and Export World*, October, 1938, p. 28, Vol. LXXVI., No. 909.

INSECT PESTS OF RICE.* LB.

(*John L. Froggatt, B.Sc., Entomologist.*)

Although the cultivation of rice has not so far developed into an important agricultural industry in this Territory, small areas have been planted in several parts, and areas in the Rabaul-Kokopo and Talasea districts have been kept under observation by the Entomologist and other officers of the Department of Agriculture, and the following found to be the principal insects associated with this crop:—

LEPIDOPTERA—		
	Pyralidae	—*Marasmia* sp.
	Hesperidae	—*Panara cinnara* Wall.
	Noctuidae	—*Cirphis unipuncta* Haw.
HEMIPTERA—		
	Coreidae	—*Leptocorisa* sp.
	Pentatomidae	—*Nezara viridula, L. smaragdula* F.
	Colobathristidae	—*Phaenacantha* sp.
COLEOPTERA—		
	Halticidae	—*Apthona bicolorata* Jac.
	Curculionidae	—*Exopthalmida rustica* Fst.
		—*Coptorrhynchus* sp.
	Coccinellidae	—*Coccinella 8-maculata* F.

Insects causing material damage to the polished grain in store are—

LEPIDOPTERA—		
	Pyralidae	—*Ephestia cautella* Wlk.
		—*Corcyra cephalonica* Staint.

LEPIDOPTERA (Moths and Butterflies).

Marasmia sp.

This is a small moth measuring about half an inch across the outspread wings; the general colour is light brown, with a darker brown margin around the wings, which have rather a semi-transparent appearance.

The eggs are laid on the foliage, and the grub, on emerging, rolls the leaf around on itself, forming a tube in which it shelters, and feeds on the surface tissue of the leaf. Pupation takes place within the tube. Where the pest is plentiful, an appreciable greying of the flag of the rice is noticeable, due to the dead areas of foliage resulting from the feeding of the grubs.

The larvae of this moth are heavily parasitized by a small *Braconid* wasp, as yet unidentified.

Panara cinnara Wall.

This "skipper" butterfly varies from dark brown to almost black in colour with two white spots in the middle of each forewing, and measures about 1¼ inches over the outspread wings. The caterpillar fastens two or more leaves together with "silken" threads, and feeds at night. Pupation takes place inside the shelter thus formed.

This species was bred on several occasions from larvae collected in the Rabaul-Kokopo areas.

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* Identifications were obtained through the courtesy of the Imperial Institute of Entomology, London.

Cirphis unipuncta Haw.

This "cutworm" moth was bred from material collected in the Talasea area. The grubs live in the soil near the base of the plants, and come out to feed on the foliage at night; they are brownish-black in colour. Where plentiful, a poison bait will kill the grubs readily. (*See* later.)

The adult moths are a biscuit-brown colour, and about 2 inches across the outspread wings.

HEMIPTERA (Plant Bugs).

Leptocorisa sp.

This is a long slender bug, measuring about ⅝ inch in length and about ⅛ inch in width; in colour the adults are a light greenish brown.

Both adults and nymphs suck the sap of the head of grain when very young in the "milk" stage, with the result that no grain forms in those parts attacked—where the pest is numerous, whole heads may be affected—and such parts go white, giving rise to the name of "whitehead" to the damage done by these pests.

Nezara viridula, L. smaragdula F.

In the adult stage, this bug is green in colour, and measures about ½ inch long and slightly less in width; all stages of the life cycle, from small nymphs to adults, are sap-suckers, and are mostly found on the rice heads. At times they are extremely numerous.

This species is also prevalent on beans.

Phaenacantha sp.

This is another slender bug as compared with its width, measuring about ⅜ inch long and about $^{1}/_{16}$ inch wide; in colour, it is reddish with a black patch on the top of the thorax.

This species is very active in movement, and is generally found on the seed heads; it is also a sap-sucker.

COLEOPTERA (Beetles).

Apthona bicolorata Jac.

This is one of the "flea beetles", so named from the habit of jumping when disturbed. It is a small brown beetle with a black mark along the middle of the back. It feeds on the flag (foliage), and blossoming heads of rice.

Exopthalmida rustica Fst.

This grey weevil is very variable in size, being usually about ½ inch long. It feeds on the foliage of a number of plants, and has the habit of shamming dead and falling when disturbed.

Coptorrhynchus sp.

This is a small weevil less than ½ inch in length, and a dark grey in colour. It feeds on a variety of crops.

Coccinella 8-maculata F.

This is one of the "ladybird" beetles. It is usually reddish in colour with eight black spots on its back, and it feeds on foliage.

Control Measures.

In most cases the areas under rice were small, and, where necessary, hand-picking could be resorted to. In cases where this is too slow a few notes are given below for general guidance.

With bugs and other sap-sucking insects, any spraying measures undertaken should be carried out in the early morning, when the insects are more or less comatose. Spraying with any strong contact spray, such as kerosene emulsion, or miscible oil sprays, should suffice, especially if this is done while the bugs are in the immature (or nymphal) stages, when they are much more susceptible to treatment than after they reach maturity.

With the adult bugs, it is possible with many types to wait until the insects have become active, and send a line of boys through the crop armed with cardboard or leather "swatters" coated with "tanglefoot", and as the bugs fly on being disturbed, strike them with the "swatter", and catch them on the sticky surface. Numbers can be killed in this way in a short while.

Beetles that have the dropping habit when disturbed can be readily collected in a tin or other suitable receptacle held under the heads or flag, and then shake the stalks; the beetles drop into the tin and are then easily destroyed, especially if a little water and kerosene are placed in it before starting out.

Cutworm caterpillars are readily killed by preparing a bait of the following composition:—

Bran	25 lb.
Paris green	1 lb.
Molasses (or treacle)	1 quart
Lemons (or moolies)	2 fruits
Water	about 2 gallons

The bran and paris green are thoroughly mixed in the dry state, and the molasses and chopped-up lemons mixed with portion of the water.

The liquid is worked into the poisoned bran, and, if necessary, more water added, so as to give the final consistency as just crumbly.

This is best prepared in the morning, and scattered around the base of the plants in the late afternoon.

Moth Pests of Stored Rice.

Two small moths, *Corcyra cephalonica* Staint. and *Ephestia cautella* Wlk. (family *Pyralidae*), cause considerable loss to rice in storage in sheds in the Territory, the grubs feeding on, and matting together, the grains, forming tubes; a thick mass of these tubes is often found on the inside of the bags when opened. Both species have also been bred from cocoa beans which have been bagged and stacked in sheds with rice and copra.

The adults of both species are grey to brownish grey, and measure from ½ to 1 inch across the outspread wings.

Fumigation with subsequent storage in insect-free sheds will control the pests, but with the conditions existing at the ports of concentration of rice this is a practical impossibility. Treatment of sheds as soon as a shipment has been cleared out will help to minimize the trouble, but this must be done thoroughly to be effective.

FALL OF MATURE COCO-NUT PALMS IN NEW GUINEA, DUE TO SOIL CONDITIONS.

(*R. E. P. Dwyer, B.Sc.Agr., Economic Botanist.*)

Falling of mature coco-nut palms due to soil conditions, bad drainage, and so on, is not an uncommon occurrence in some plantations in New Guinea. The bending over of palms on water-logged, low-lying situations, or in peaty soils, so that they almost touch the ground, is a common indication that palms are growing on such soils. Often, though not invariably, such palms fall completely to the ground. They usually remain stunted or low in height, chlorotic and poorly bearing, until drainage is improved.

On one plantation in Buka Island (Small Buka),* coco-nuts are grown under very wet conditions, where extensive drainage has been found necessary. The low-lying nature of the ground, as seen where the water is always slowly running in the shallow drains and around the roots of the palms, has caused many of them to fall over, due to their restricted rooting system. Some of these palms still continued to grow upwards from the tip. The roots at the base are not wholly severed, and such palms may grow on for years, and even produce moderate crops of coco-nuts. Similar areas to those mentioned are known in New Britain and other parts of the Territory, but the example quoted in Buka is an extreme case, where a large area of coco-nuts was planted under wet conditions.

On another plantation in Bougainville Island, a different set of soil conditions is found which has also led to the fall of mature palms over a fairly extensive area. In this case, the surface soil is light and relatively sandy over a large flat area of country. The plantation is a very good, heavy-yielding place, and the coco-nuts generally look strong and healthy, although the planting is closer than usual (probably about 27 feet spacing).

The light soil at the surface does not, on first appearance, appear rich, but under the sandy layer a distinct retentive, clay layer exists at a little distance below the surface. Water is continually moving from the high foothills behind. Through and above the clayey layer there is a continuous slow movement of water, probably carrying dissolved nutrients in it. In the plantation, the water comes almost to the surface during the wet season, and thus drainage under such conditions was found necessary. It is not in the frontage areas, however, that the fall of palms occurs. It is at the back of the plantation, where the soil is lighter on the surface with more pumice mixed in with it, that a proportion of the mature palms fall, though, of course, the silt or clay layer still persists underneath. In the worst areas there is some evidence of swampy conditions in the near past. In such areas the soil is stiffer at the surface, and clay bands have reduced the natural drainage, which in turn has restricted the root area of the palms, and thus, in heavy winds, there is a decided tendency for the palms to fall.

The palms which have fallen on this plantation show a distinct ball of roots and earth at the base. The broken roots appear to have died and decayed owing to lack of aeration, and, in some cases, the fungus *Fomes* spp. was seen to be present. This was not the cause of the trouble, however, as the fungus was not always present. It appeared that the light upper soil could not hold the roots firmly, where the shallow-rooting tall palms had not penetrated far into the sub-soil, or else the roots had rotted off due to excess water and bad aeration. In several localities, shallow planting on heavy, clayey soils appeared to be the main cause of the mature palms falling over.

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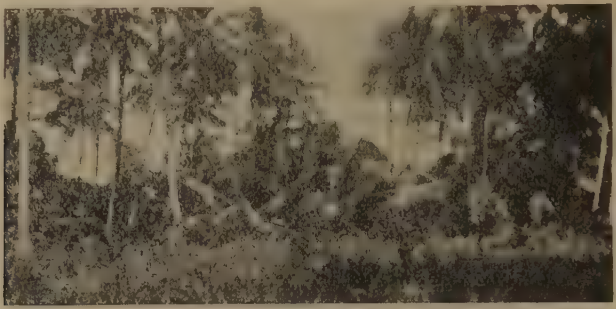
* Buka Island or Small Buka is north of Bougainville Island, one of the Solomon Islands Group, and is only separated from it by the narrow Buka Passage.



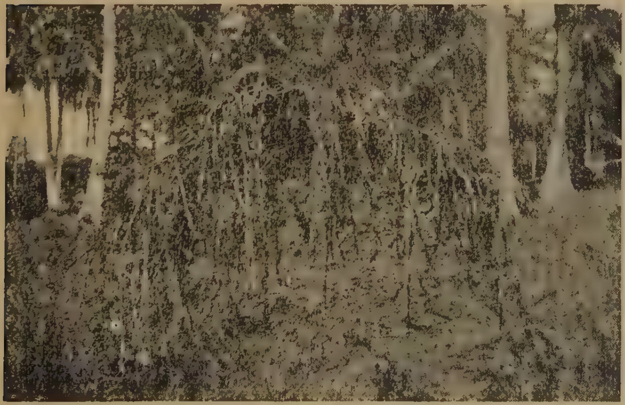
SHOWING AREA OF FALLEN PALMS, WITU ISLAND.
N.B.—Growth continues vertically at their extremities.

In the Witu group, it was noticed, in some areas, that tall palms planted in 1912, and now aged about 26 years, fell down after heavy winds. These palms were fully bearing and appeared quite healthy, prior to falling. The fronds were dark green in colour and there was no sign of chlorosis, tapering stem, or other deficiency diseases. The palms fell over, particularly in a high wind, and though no detailed counts were made at least a couple of hundred of palms had fallen, particularly in one belt on a large, low-lying area.

FALLEN COCO-NUT PALM.
Showing growing point vertically and at right angles to the fallen trunk.

The fallen palms have a peculiar and distinctive appearance, as they do not die altogether, but continue growing from the head, which turns at right angles from the ground and the main trunk as it lies. The size of the fronds becomes noticeably smaller than on mature palms or compared with fronds which would be seen on palms of comparable age and size (*see* photographs). The diameter of the upright portion of the trunk is decidedly smaller than the main trunk. These growth habits indicate that less nutrients are taken in, which is accounted for in the reduced rooting surface and feeding area, after the palms

ROOT SYSTEM OF FALLEN COCO-NUT PALM.
Close view showing Root Plate of Matted Roots, taken at Witu.



ROOT SYSTEM OF FALLEN COCO-NUT PALM.
Same subject as above, taken at a greater distance away.

have fallen down. The fallen palms do continue to flower and fruit, but never thrive satisfactorily, as could be expected, when the reduced leaf area and nutrient intake, and the shading from the surrounding palms, are taken into account. The nuts produced are smaller and fewer when they do commence bearing. It should be noted that the palms do not fall until fully grown, and some of those which had fallen were probably 40 to 50 feet long.

An examination of the root system of a fallen palm is most illuminating (*see* photographs). The roots do not break off as would be the case where a normal palm falls, due to other causes, such as washaways, &c. Except at the outside periphery of the palm roots, more than two-thirds of the base is entirely flat and compressed, though there were some exceptions which are described. In these exceptional cases, the centre of the palms has roots protruding as an ovate or round ball, at the base of which the roots are severed. The explanation of why this ball of roots occurs in the central basal portion of some palms appears to be associated with the size of the original planting holes. Where the holes were made larger than usual, the roots were able to penetrate deeper in an area corresponding with the size of the hole. A great proportion of the palms showed no evidence of this secondary bole whatsoever.

The flattened roots which had not been broken at all, except at the periphery, showed every evidence of a " soil-bound " condition, or an effect similar to that which is brought about where large plants are grown in small earthenware pots in the garden or nursery, and the roots are compressed into a small space. The great mass of compressed roots at the base were curled and twisted into a labyrinth of matted roots, which were almost as flat as a plate where they had been in contact with the ground surface. This interwoven mass of twisted roots could be termed a " root plate " caused by enforced restriction of the rooting and feeding area. It was apparent that a detailed examination of the soil profile was necessary to solve the reasons for the flattened appearance at the base of the palms.

Soil sections which were exposed in gullies, exposed foreshores, cuttings for small railway trucks, &c., were examined. The appearance of the actual soil conditions at the base of the palms was most instructive. The first 12 to 15 inches of soil was a reddish-brown chocolate and very friable, volcanic loam which, on appearance, seemed to be chemically and physically a rich soil. The chemical richness of the soil is easily confirmed, as the plantations there yield well over a half a ton per acre per annum (in the vicinity of 14 cwt.), which must be classed as good, high-yielding property. It appeared that so far there was practically no evidence of soil deficiency, and the only weak palms present were hereditarily or genetically so, and such palms can be seen on almost any plantation. The next underlying layer extends for more than 8 inches in thickness, and is definite hard-pan, which is found under a fairly wide area of ground. This layer is very hard and proved difficult to pierce, even with a crowbar. When dug out the hardened material breaks into a fine palpable mass, when pounded, or else comes off in definite flakes or layers in much the same way as shale does. The next underlying layer to the above, when reached, proved not quite so compacted as the above, being composed of a matrix of greyish ash comparable with the hardened layer, but mixed with volcanic scoria. The scoria and rocks found in this matrix appear to be very variable in colour and composition. This last layer is very deep but variable, being composed of several layers apparently as the result of many upheavals. Curiously, in many sections, a second hardened layer, comparable with that described previously, is met at about 4 feet depth. This appears very similar in appearance to the top hardened layer, but may not be the same in composition. It is the first hardened layer met with which is responsible for the plating and compaction of the roots at the base of the coco-nuts, as it was practically impenetrable to root growth, even by roots so hardened as those of coco-nuts. A native boy had considerable difficulty in digging through this layer when soil samples were being taken, as it was extremely fine-grained and very hard. Semi-weathered, flat pieces of this hardened ground (mud-stone) up to about ½ inch in thickness were seen, in numerous instances, to be attached to the flattened basal roots, and sometimes very fine roots had penetrated partially through this material. The compacting of the roots against this hardened layer explains the origin of the basal plate of roots.

When one walked along the roads and paths where the washing away had exposed this hardened layer at the surface, it was found to be very slippery and very hard. As far as could be gathered it was almost impervious to water, especially when flowing quickly and in quantity, and the loose surface soil was easily eroded away from it, indicating that cover cropping would be valuable. Wherever any low-lying areas are present, the water tends to collect in wet seasons and thus the root system becomes even more restricted in such places from this cause. The topography is, however, usually undulating, with a moderate grade towards the beach which provides a ready get-away for the water through the pervious, rich top-soil. Owing to the presence of this hardened layer, no deep gullies or creeks are present, which limits the available water supply. The ability of such a relatively shallow depth of soil to support such good coco-nut palms is testimony of its richness. It is also plain that coco-nuts can flower and give good production with a very limited root-system, providing the soil is really good.

The palms under the conditions where the hard-pan exists are entirely lateral rooters. This habit offers an interesting comparison with deep-rooting palms seen in washaways or sections exposed by the heavy rains after the volcanic eruption in the soft, deep pumice soils close to Rabaul. Here it was seen that the roots of a young palm (about eight years old) reached a depth of at least 30 feet.

The explanation as to why the palms fall only when they are fully grown and have reached a good height appears to be a question of increased leverage, which is assisted by strong winds, where the root-hold is weak. The soil, as said before, is sufficiently good as to maintain a heavy leaf growth, plus a heavy yield of nuts. It is probable that the tops of the palms reach a maximum weight at a particular height and curve backwards and forwards through a greater number of degrees in heavy winds, when they are tall, than when they are short and carrying even the same or may be a heavier crop. The root anchorage is not deep because of the hard-pan mentioned, so that in heavy winds there is a tremendous strain placed on the roots. It becomes heavier and heavier until eventually a breaking point is reached and the palms fall down. The roots at the edge of the hole on the side closest to the ground are not even severed, and they continue to supply a certain amount of nutriment to the fallen palm, leading to its eventual re-growth at the growing point. Soil and rubbish are sometimes heaped around the unsevered roots to assist the continued growth.

It is evident that, although such palms continue to grow, the roots can never supply enough nutriment for the fallen palms to enable them to become heavy bearers again, though they might conceivably assist in shading the soil.

The reason for certain low-lying areas being more liable to the fall of palms is associated with less aeration and weaker root development where the water is close to the surface, and not moving quickly. The soil is also softer when wet, which leads to an earlier fall of the palms.

It appears likely that the area, where this fall of mature palms occurs, may extend somewhat as the palms become older and higher. This may not reduce the value of the places to any great extent as the fall of palms is due to weak root anchorage and not soil deficiency, hence, replanting should prove practical, if any considerable areas are affected in the future. The re-plant palms would need to be planted away from the original holes, and then they should continue to grow and yield again for many years. The experiences of re-planting lightning-struck areas, where the soil is rich, would confirm this opinion, as they were seen to come away well indeed in similar areas to those under consideration. It would be almost a waste of time to re-plant such misses if the soil were poor.

FALLEN COCO-NUT PALM, WITU ISLAND.
Trunk, showing growing point, with length and development otherwise normal.

Dynamiting or Explosives.

This is, apparently, a case where the use of explosives in the original planting holes was indicated and, in fact, it was said that dynamite was used on a small scale in some of the original plantings. After these operations, plenty of top soil should then be drawn into the enlarged holes. There is no danger of compacting the surrounding soil by explosives where such a hard-pan exists, and the hardened formation should give good results from such treatment.

Origin of the Hard Pan Layers.

This is really a question for the geologist and soil chemist and soil samples were taken for submission to Institutes dealing with such problems. It might be pointed out that the areas, where this fall of palms has occurred, are composed of geologically new soil, comparable with the whole of Witu Island. These islands are certainly volcanic in origin and, according to observers, John Albert (Johann Albrecht) and Peterhaven are practically breached craters filled by the sea. The predominant rock is stated by Stanley* to be "Augite Andesite," covered with a thick deposit of scoriaceous material, tuff and pumice, which, apparently, makes a fine soil for the growth of cacao, coco-nuts and rubber. The fact of its recent origin is also shown by no large virgin forest trees being present. There is a large proportion of *Albizzias*, Breadfruits (*Artocarpus* spp.), *Eugenias*, Galips (*Canarium* spp.) and other fruits present, a large proportion of which were, apparently, planted by natives in the first instance.

The John Albert Harbour still has hot springs near the entrance and this is one of the best examples of a submarine crater one could find. The areas where the falling palms are found are situated on what appears to be the slope of the raised lips of this crater. When this large rim was built up further volcanic activity occurred on the raised land and thus a newer land crater is found, facing these slopes. The chances are very probable that the top layer of good soil was derived from weathered rock of lava flows from this land crater, as the country rock here appeared to be a fine grained basic basalt. There are hard lava belts present, which are so young that they have not weathered sufficiently to support other than short vegetation, and coco-nuts, not at all. The rich, red, chocolate soil at the surface is derived from weathered basalts or Andesites. The hard pan layers appear to be derived from submarine volcanic disturbances. They are greyish in colour, and very fine grained and compacted, sometimes with contained small fragments of rock. In texture and appearance, it is very like the fine grained compacted mud thrown out of Matupi Crater during the recent volcanic eruptions in Rabaul.

The incidence of the mud-stone layer appears to be confined to comparatively limited areas of the island, and lies approximately in one direction. This again is comparable with what occurred at Matupi, where only an isolated, locular-shaped area was covered with mud. Saturated fine volcanic ash does not appear to be thrown very far out from the original focus, which is apparently due to its relative weight or high specific gravity. The lower layer of similar type apparently represents the results of earlier submarine eruptions. The central layers of scoria appear to be derived from a more explosive volcanic activity acting over a fairly wide range of time. It is also feasible to believe that the gradual sifting action of rainfall would assist in compacting such layers. A chemical and physical examination of these soils is intended and should provide interesting data concerning the profile described and its origin.

Fall of Mature Palms at Manus, Admiralty Islands.

During a recent visit to Manus, it was noticed that some patches of mature palms, growing on the coralline fringes of certain plantations, had fallen over, although the palms were otherwise healthy. These fallen palms were situated on areas possessing a very loose soil at the surface, but with hard coral coming in at a shallow depth. This led to restriction of root growth at the base of the palms, while the loose root-hold in the surface layers led to their eventually falling over, particularly after heavy rains accompanied by strong winds.

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* Stanley, Evan Rd. "Report on the Salient Geological Features and Natural Resources of the New Guinea Territory." Reprinted from Report on the Territory of New Guinea. 1921–22 (Commonwealth Parliamentary Paper, No. 18 of 1923).

On one plantation at Namatanai, New Ireland, it was noted recently by Mr. F. O. Moody, Departmental Inspector and Instructor, that a number of palms had fallen down in some areas. He ascribed this fall of palms, aged about thirteen years, to shallow planting where a loose top-soil was present overlying coralline rock, which in some areas came near to the surface. Furthermore, in these areas the secondary growth had been left to grow almost as high as the palms, or in some cases higher, and this undergrowth acted as an effective wind-break before being cut down. Once this tall undergrowth was removed any winds occurring gained increased velocity, and blew the shallow planted, shallow rooted palms over.

Ninigo Group of Coral Atolls, Western Islands.

The centres of the majority of these coral islands are low and swampy, and here the palms flourish best on the higher ground between these central lagoons and the sea. The proportion of dry ground present in a particular island greatly influences its value for growing strong coco-nut palms. Although a great deal of low-lying land is planted, the palms do not flourish so well, and they tend to become stunted, poor yielders with a tendency to fall over.

It was seen that most of these small islands taper towards their longest extremities and because the soil is newer and shallower there, the palms do not grow so well as in the deeper soil, found in the raised dry areas, present on the more central margins.

Underneath the whole of the Ninigo Islands, free, underground water is present at a relatively constant depth. The differences in depth from the ground surface to the water in the various places is more dependent on the slight irregularities of ground elevation present on these low-lying islands. On the higher ground in the central margins of the island, it may be 5 ft. 6 in. to the water surface, while it rises to ground level in the lagoons.

Owing to the existence of a very porous, gritty, sand layer at almost the sea-level, the underground water here is influenced by the tidal rise and fall with a time lag, dependent on the size of the island and the distance from the shore. Owing to the various salts being absorbed and filtered in the sand layers, the water is only slightly brackish and, hence, is used by the natives for drinking purposes, without any ill effects.

In between this underground water and the surface, there is, in all of these islands, a semi-hard pan of lime-impregnated sand, which, in most areas, restricts the access of the coco-nuts to the free water.

The holding up of the surface water by the lime-impregnated layer would tend to cause waterlogging in very wet seasons, as is periodically experienced. It is also a curious fact that despite the presence of free, underground water, the palms on these islands do feel the effects of prolonged drought, when the surface layers above the hardened lime layer are dried out.

In the low-lying lagoons or swampy depressions, it is the excess of free, brackish, rather stagnant water which restricts the root-growth and makes these areas unfavorable for the growth of the coco-nut palms.

The distance from the ground surface to the free water (practically at sea-level) determines the depth of rooting in such cases. In the swamps and semi-waterlogged areas, where the palms become dwarfed, lean over, and either partially or completely fall out of the ground, root-restriction due to waterlogging, is indicated.

Where the roots of such fallen palms are not entirely severed, the crowns commence to grow again, vertically at their growing point, but in such cases, they usually flower sparsely and give poor production.

The fall of mature palms on some areas in the Ninigo Group was definitely associated with the compacted layer already mentioned, especially where it was underlying the loose, sandy soil at a shallow depth.

In an examination of different soil profiles here, it was seen that at varying distances below the surface (never much greater than a couple of feet), this stiff, puggy layer of compacted sand was to be found and its consistency was comparable with mortar.

The origin and formation of this layer is explained by the fact that the calcareous or limey sand has great facility to become agglutinated into a clay-like layer of calcareous mud. The deposition of the layer is due to the leaching action of water taking the lime into solution, and depositing it into distinct layers at limited depth. Here it has a mortarizing effect and firmly cements the fragments of sand together, making the whole mass difficult to dig out. This layer is not altogether impervious to the coco-nut roots, but it badly restricts their spread and growth into the deeper layers. It also causes the roots to become thin, spindly and weak, thus providing a distinct break in the root system at the zone, where the restriction occurs. It is in patches where this layer is found close to the surface, such as where surface irregularities are present and the palms are growing in the low-lying patches, or where surface erosion has occurred, that the palms are most liable to fall over.

In all of the profiles examined in these islands, the depth of rooting, though variable, ranged from shallow to moderate depths only. The depth of rooting, apparently, was influenced by several main factors, such as, depth and age of the soil, presence of hardened sub-soil layers, distance to water table, and whether the palms were growing on the rim of islands, in, or near, the central lagoons, or at the extremities of the islands.

An attempt is made to describe, from a typical dry land profile on which the palms are growing well, what may be taken as approximating the prevailing coco-nut-root distribution in the Ninigo Islands. This description does not fit those areas where the palms are so shallow rooting as to have fallen over, as there the compacted layers are nearer the surface.

In the first 4 inches to 9 inches of soil, comprising the humus layers, the fibrous coco-nut roots are densely scattered as feeder roots.

At about 4 inches to 6 inches depth, it is usual to find that a compacted layer of larger main roots comes in which are mixed with the fibrous roots for a depth of a few inches.

These main lateral roots extend throughout the soil and sub-soil until the plaster-like layer is met, usually at about 2 feet to 2 ft. 6 in. After passing through this compacted layer, the larger, main water-feeding roots come to a looser layer of semi-saturated, gritty sand, and extend right to the free water surface. As mentioned before, the lime infiltrated zone has a constricting effect on the root system. The roots in the looser, sandy layers, below the lime layer, are generally evenly distributed, but are often constricted, gnarled and discoloured, and do not appear so healthy, or well developed as in the upper layers. This is not always the case, because in several instances, what appeared to be perfectly healthy roots were seen in the water saturated zone.

Most of the native trees present in the Ninigo Islands are not deep-rooted, especially in the shallow lagoons where shallow, prop-rooted trees, such as Mangroves and species of Ficus are usually present.

Decided evidence of the influence of the underground compacted layer, mentioned, on the rooting system of the original bush trees was seen as Pelleluhn.

At the end of one small island, some large Casuarina trees, several feet in circumference, were observed growing on a comparatively shallow sand-spit. Two of these Casuarina trees had fallen over, and it was noted that despite the size of these trees, their roots had not extended much more than one foot into the ground.

The whole root system was completely flattened at the base, showing that the roots were living on the surface humic layer only. Owing to the shallow root-hold, the trees had fallen over when undermining and heavy winds had taken effect. The dense flattened mass of interlaced roots present, was closely comparable with what had previously been seen on certain coco-nut palms, which had fallen down.

Some of the roots present in this mass were as large as the limbs of a man, and these were intertwined with thousands of smaller roots, mainly feeding, fibrous roots.

Specific Instances of Fall of Mature Palms, Ninigo Group.

On the main areas of Ahettin and Paleotola Islands (Pelleluhn Plantation), also at Mal Island, shallow rooting was so apparent that many of the palms had actually fallen over on the relatively dry land. Restricted and shallow rooting was also observed on palms growing on the poorer areas of the islands, comprising Longan Plantation.

On one fairly extensive area on Mal Island, a little distance away from some areas of unfallen bush, it was seen that about 50 per centum of the palms growing under semi-swampy conditions had fallen over. In most instances, large rounded-shaped plates or balls of soil were left firmly attached to their bases. A large percentage of the palms, however, still continued to grow vertically from their crowns. In this instance, the surface soil was loose and sandy, while the palms, being shallow rooted with a weak hold, were liable to fall over in heavy winds.

In Ahettin and Paleotola Islands, it was observed, in some areas, that coco-nut palms had fallen completely over, and that many of these fallen palms had flat plates of hardened mortar-like ground attached to their bases. The depth of the rooting system was often only 18 inches in such instances. It was seen that, although some of the palms may have struck outliers of original coral, the hardened plates were usually derived from the hardened lime layer mentioned.

On the north end of Paleotola Island at 80 yards from the beach, the water-table was only 1 ft. 9 in. to 2 feet below the surface and here, in most cases, the palms were short and shallow rooted.

After heavy rains these areas become boggy and the water lies on the surface, though in the dry season, the same ground is relatively dry.

In such places, exposed masses of broken off prop-roots are seen to be covering the trunk for upwards of 3 feet above ground level. This is either due to the trunks being pushed upwards as the basal roots press against the hardened sub-soil layers or due to the ground sinking and leading to the same effect. One such palm examined was at least 50 feet high with a large, well-developed trunk, and a very heavy bunch of exposed and broken off prop-roots at the base. This palm which had recently fallen, showed very healthy fronds and had been forced over because of the restricted root-growth not being able to anchor the palm, when it had grown sufficiently tall and heavy.

At Sakalin Island, palms undermined by sea-shore erosion appeared very shallow-rooted, being flattened at the base, with the fibrous roots curled, matted and pressed closely to the lime-infiltrated, hardened, sand layer.

It might be pointed out that, at times (e.g., in 1932), some heavy gales are experienced accompanying sudden squalls in the Western Islands, and such occurrences in the areas described, assisted in blowing the palms over.

Relation of Restricted Root Development to Nutrient Intake.

It comes within another province to discuss the effects of root restriction, such as is described, on the nutrient intake and the yield of coco-nuts, nevertheless, a brief mention of the problem is thought desirable.

It the Witu Island Group, as already indicated, palms are found to be flourishing despite the fact that their roots could not penetrate more than 18 inches at the most, owing to the presence of hardened rock-layer underneath. In these islands, it was indicated that the surface soil was of volcanic origin, and chemically rich and friable. It is thus evident that shallow and restricted rooting of coco-nuts may not be detrimental to their healthy growth and heavy bearing propensities, providing that the soils are rich and that there are plenty of nutrients available in the soils to which the roots have access.

Where nutrients are not so plentiful, any restriction of the rooting system will most certainly have a more adverse effect on the life of the palms. This is most likely the case on those particular Western Islands, where it is believed that the soils, being sandy and shallow, are relatively poor in total nutrients, though these were readily available.

In this regard, chemical analyses are to be made.

The experiences in these islands, however, tend to bear this contention out, as, usually, the palms, though coming into bearing and producing excellently for some years have a relatively short period of maximum production.

It is found also that there is a very close relationship between the times of planting and the times at which the production tends to retrogress. There are other factors involved, such as original derivation of the soil, its nature, i.e. physical and chemical qualities, type of ground cover, original planting methods &c., which cannot be discussed here.

This physical adaptability of the root system of a coco-nut palm to its environment, as for instance, where the palms can flourish, although the roots do not penetrate deeper than 1 foot, providing the soil is good and sufficient water is present, provides a very good explanation why they do so well under such a wide diversity of conditions.

Erosion of Foreshore Areas.

Erosion of foreshore areas, accompanied by loss of coco-nut palms, is of common and regular occurrence in many parts of New Guinea, but more particularly on the island properties. Small islands have a large proportion of foreshore in proportion to total area, and are thus particularly susceptible to foreshore erosion, and loss of palms. Such loss of palms is very difficult to check on the foreshore fringes of the larger plantations situated so that the presence of bays and swirling currents, assisted by storms and heavy breakers, lead to the undermining and loss of old palms.

In some places, planting of *Ficus elastica, Casuarina* spp., &c., has been tried to lessen the effect, while in other areas, the original beach-loving trees, such as *Calophyllum inophyllum* and "Kwila", *Afzelia (Intsia) bijuga*, have been left in an attempt to remedy the position.

Erosion of foreshore areas is usually difficult to avert and attempts at prevention must depend upon the circumstances under which the erosion is occurring.

Heavy Floods and Shifting River Mouths.

In many parts of New Guinea, many hundreds of coco-nuts have been washed away. One plantation on the mainland has been greatly reduced in value, owing to a shifting river cutting right through the plantation.

Where short and rapid rivers are present, as in many of the islands here, losses from this cause are always likely to occur.

Washaways and Fall of Mature Palms following on the Recent Eruption—Rabaul.

Serious washaways consequent on the heavy storms following the eruption, caused widespread loss of palms and permanent damage in five plantations on the north coast of the Gazelle Peninsula. The compacting and sealing of the volcanic dust did not allow of the heavy rains penetrating to the porous soils underneath and, hence, surface run off became serious. The effects were particularly serious, where many ravines and low-lying gullies were present, such as at Kurakakaul Plantation, where several thousands of palms (estimated at 5,000 palms) were carried away. In some of the larger ravines, the coco-nuts were washed out by the roots and carried out to sea. The extent of these washaways can be judged by the immense deposition of new land which occurred at the sea shore.

Very serious damage was also caused, particularly in the native groves, by the breaking over of the palms due to the extremely heavy winds following the uption. Palms which were suffering badly from soil deficiency and tapering stem, were most affected. In the zones of greatest deposition, the heads of the palms were full of pumice dust and mud, and the heavy winds caused the heads to fall over under great pressure and, in almost every case, left a large split or gash on that side facing away from the wind. In some instances, the palms were so affected by the heavy winds as to have their fronds turn inside out, like an inverted umbrella.

As this damage due to the volcanic eruption is caused by unusual circumstances, it is not proposed to discuss it in detail in this article.

Summary.

Some occurrences of the falling of healthy, mature coco-nut palms in New Guinea plantations associated with particular physical soil and sub-soil conditions, are described. The appearances of such fallen palms and their compacted root system are also given.

In some areas of Buka Island, swampy conditions are associated with the fall of mature coco-nut palms.

In Bougainville Island, the presence of loose, sandy soil with an underlying retentive, stiff, clay sub-soil, which led to water-logging and root restriction, was the apparent cause.

At Witu Island, the fall of palms is found where the underlying country rock is geologically recent and only weathered to a shallow depth. Here the loose, friable, volcanic loam, which is rarely much more than 15 inches in depth, leads to shallow rooting.

At Manus, palms fall over where loose, sandy soil overlies the original raised coralline rock. A similar occurrence is recorded from New Ireland.

In the islands of the Ninigo Group of coral atolls, there are at least two causes, which may be inter-related, leading to the fall of mature palms. In some places, the presence of a raised water-table in the central swamps and lagoons leads to root restriction and fall of palms. Elsewhere, the fall of palms was often associated with the presence of a compacted lime layer formed by deposition and underlying a loose, sandy soil.

This compacted, mortarised layer is found in most coral atolls, and leads to root restriction, where water-logging occurs.

The explanation as to why palms fall only when they are fully grown and have reached a particular height, appears to be related to increased leverage, due to greater weight and height, causing the palms to fall during heavy winds.

Coco-nuts can flourish and produce normally with a very restricted rooting system, providing the surface soil is physically and chemically rich. Where the soils are poor or compacted, root restriction and water-logging will finally lead to deficiency symptoms and soil exhaustion becoming apparent.

It is clear from these observations that from a practical stand point, the study of soil profiles, yields much information concerning suitability of particular areas to coco-nut cultivation, even where chemical data is not available.

The planter or intending planter should be cognisant of the presence of hard-pans in his coco-nut areas, whether due to the natural country rock coming to the surface, or to deposition of lime, iron or other minerals.

Acknowledgment.

The photographs accompanying this article were taken by Mr. E. Hann, Plantation Manager, Witu Group.

THE COCO-NUT OIL INDUSTRY.

(*By A. E. Williams, F.C.S.*)

Although coco-nut oil has been used extensively by the natives in the tropical lands of its origin for many centuries, it was not exported to European countries in any appreciable quantity until the middle of the Nineteenth Century. At that time the industry was entirely in the hands of the natives, who expressed the oil by very primitive and unhygienic methods, so that the resulting product was vastly inferior to the oil produced in recent years. As the demand for coco-nut oil increased, due chiefly to its adoption in soap manufacture, the crude methods of producing it were improved, and the systematic cultivation of the coco-nut palm was commenced.

In 1907, nearly 3,000,000 acres were under cultivation, and, at the present time, there are approximately 7,000,000 acres devoted to the cultivation of the tree, of which area more than one-half is in the British Empire. India possesses the largest area under cultivation, but this is no indication of the amount of oil or copra exported from that country, as owing to religious scruples forbidding the use of animal fat as a food a large proportion of the natives rely entirely on the locally-produced vegetable oils. The bulk of the copra and coco-nut oil exported to European countries is from the Dutch East Indies, Philippine Islands, South Sea Islands and Ceylon. In addition to the cultivated areas, there are vast tracts of land containing uncultivated coco-nut palms, the extent of which has not yet been estimated. The chief botanical species cultivated is *Cocos nucifera,* which is essentially a coastal plant, being rarely grown successfully at considerable distances inland. From the time of planting about seven or eight years elapse before the tree begins to bear fruit; the bearing period is from 60 to 70 years, each tree yielding annually from 80 to 90 nuts. Many of the larger plantations are equipped with testing stations in which work on the production of seedlings for future use is carried out. In some districts it is the custom to gather the nuts from the trees before fully ripe; by so doing it is said that the copra will keep longer and possess a higher oil-content than would be the case if the nuts were allowed to fully mature before harvesting.

Copra Production.

Copra, or the dried broken kernels of the whole fruit, represents about 30 per cent. by weight of the nuts as taken from the trees. The splitting of the coco-nuts is generally done by hand; although in some districts machinery is in use for this purpose, it is found to be not much quicker than native labour. Much of the copra exported is produced by sun-drying the broken nuts, the latter being spread out in thin layers in the open and left for a period of from five to eight days.

During this process the kernel separates from the hard shell, and the moisture content is reduced to about 8 per cent.; this is further reduced by gradual evaporation of water during transport and storage. The result is that copra arriving in European ports seldom contains more than 5 per cent. of water, the oil content being from 65 per cent. to 70 per cent. In many districts the nuts are not sun-dried, but recourse is had to artificial means, and there are a number of efficient dryers available for the purpose. Generally, artificially-dried copra has a more uniform moisture content, and frequently yields a better quality oil than the sun-dried product. In the sun-drying of coco-nuts, which occupies about one week, putrefaction often takes place, and the oil expressed therefrom will have a higher percentage of free fatty acids, and also a darker colour, The native method of drying copra by artificial means is somewhat crude, consisting, in general, of arranging the broken nuts on bamboo racks, under which a fire of coco-nut shells is lit, the hot gases and smoke from the fire being relied upon to dry the nuts. This method is rapidly being replaced by modern drying apparatus, of which an example is furnished by the copra-drying plant illustrated in Figures 1 and 2, which show one of several recently installed abroad

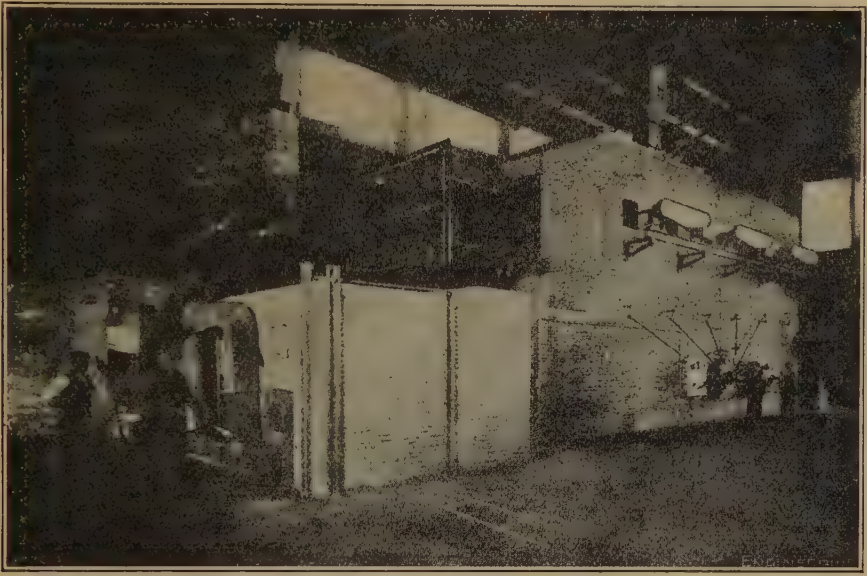

Fig. 1.—Furnace End of Copra Drying Plant.

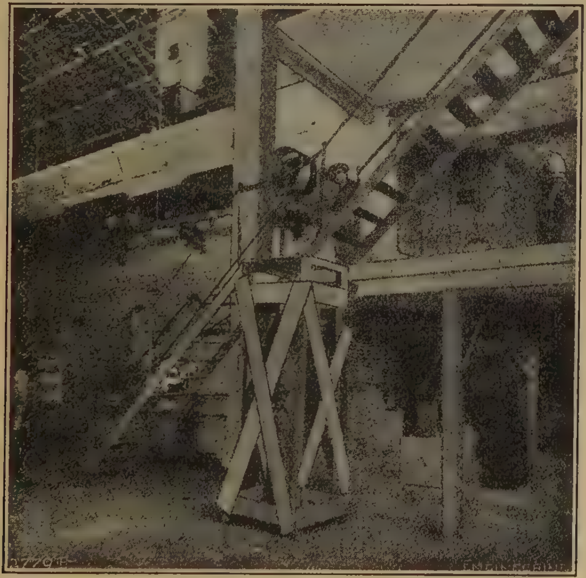

Fig. 2.—Charging End of Copra Drying Plant.

for this purpose by Messrs. George Scott and Son (London) Limited, Silvertown, London. A feature of this plant is that the coco-nut shells, available on the spot, may be used as fuel, and by a special arrangement of the furnaces the fuel consumption is very low.

The broken nuts are dried by a current of clean, maintained hot air in constant circulation, its temperature and volume being regulated as the drying of the copra proceeds. This plant has a capacity of 150 tons of coco-nuts per day, and produces a very light coloured copra, yielding a first-class quality edible oil.

Utilization of Husk and Shell.

The outer husk of the nut is frequently removed in as sound a condition as possible, as it forms the raw material of an important tropical industry. The fibrous husk is allowed to soak for several days in a week alkaline solution, whereby the material is considerably softened. It is then thoroughly washed free from alkali and dried. The product can be readily spun into a coarse yarn, from which a large number of native requisites may be manufactured. The coco-nut shells may be advantageously used as fuel for the artificial drying of the copra, or may be ground up, mixed with a suitable binding material and pressed into briquettes for domestic fuel. Both in Europe and America, the manufacture of activated charcoal from coco-nut shells is carried out on a fairly extensive scale.

Reduction of the Copra to Meal.

It is necessary to reduce the dried copra to a fine meal in order to facilitate the extraction of the oil in the presses. The reduction, or grinding, process, is usually carried out in two stages—the machine used in the first stage grinds the copra to a coarse meal, which is then further reduced by special rolls. The preliminary grinding may be carried out in an ordinary disintegrator, or, more speedily, by a machine made specially for the purpose, such as that illustrated in Figure 3. This apparatus comprises two pairs of adjustable gear-driven

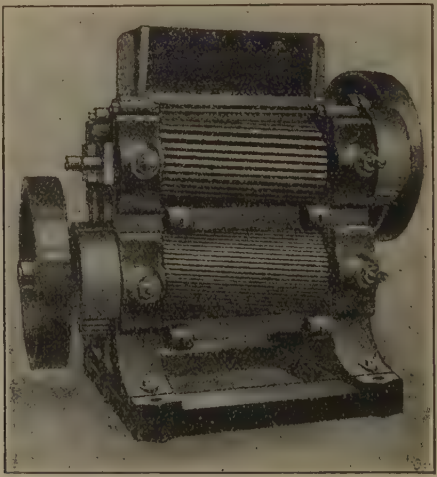

Fig. 3.—Copra Reducing Mill.

rollers, all 17 inches diameter by 4 feet long; the roll bodies are of chilled cast-iron. They are forced on to the steel shafts under hydraulic pressure, and secured by sunk keys.

A feed-hopper with shaker feed, roll-scrapers, and cover plates are included. The upper rolls are fluted, or grooved, to a coarse pitch to take the copra as received, and the lower rolls to a finer pitch to reduce the product further. The output of this machine, which is constructed by Messrs. Rose, Downs, and Thompson Limited, of Hull, is 3 tons of copra per hour. In large mills these machines are arranged in batteries of six or more, alongside of which a conveyor and elevator are installed to carry the coarse meal to the rolls for the final reduction.

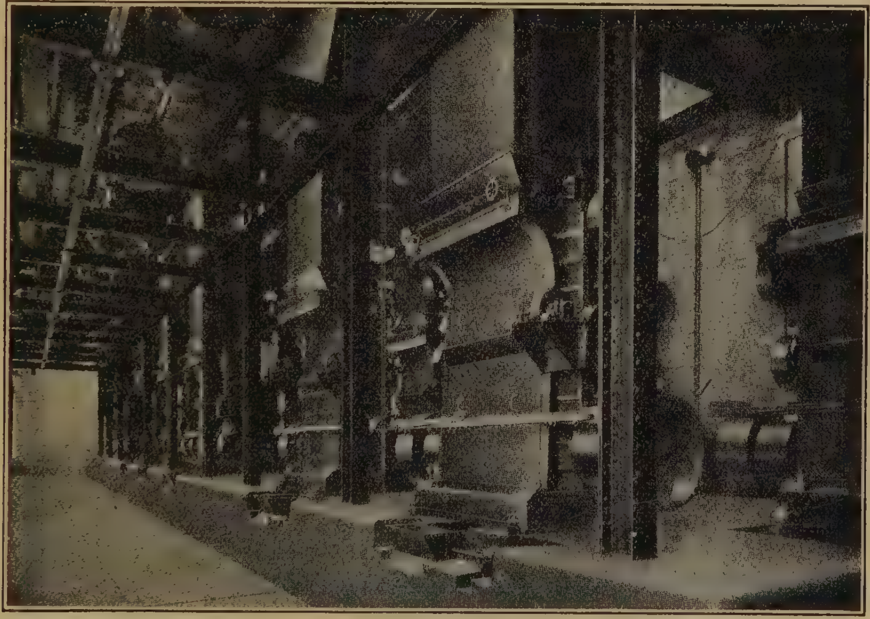

Fig. 4.—Copra Grinding Mills.

A grinding-room of a large mill, equipped with fifteen sets of Anglo-American five-high rolls, made by Messrs Rose, Downs and Thompson, is illustrated in Figure 4. Each machine comprises five rolls made of chilled cast-iron, and has an output of about 1 ton per hour. The coarsely-ground copra passes into the feed-hopper at the top of each machine, a regulator being fitted to control the rate of feed to the rolls beneath. A grooved feed-roll in the base of the hopper ensures even distribution of the meal along the full length of the rolls. From the feed-roll the meal falls on an inclined guide-plate, off which it slides between the first and second rolls. Emerging from these, a guide plate on the opposite side catches it, to pass it between the second and third rolls, and so on, until the meal in one passage through the five-high rolls is crushed four times. The rolls are compact and entirely self-contained machines. The roll shafts are of forged steel, the shafts of the top and bottom rolls having extra large bosses towards each end, where they are fixed in the rolls; the bottom roll shaft is also fitted with a barring collar. The roll bodies may be either in cast-iron or in specially hard chilled cast-iron; the latter type give generally the greatest satisfaction. All roll bodies are accurately turned and finished; the shafts are forced into the rolls under hydraulic pressure, and fitted with sunk keys. After the shafts have been fixed in the rolls, the roll bodies and shafts are ground together The rolls are driven by fast and loose pulleys on the bottom roll shaft. Plain bearings, roller, or ball-bearings may be fitted.

The pressure on the meal, and thus its particle size, may be regulated by means of a combination of compression screws and springs fitted on each machine. In general, the finer the particle size of the meal delivered from the rolls, the greater will be the oil yield in the subsequent pressing operation, for any given pressure and meal temperature. On the other hand, a finely-ground meal will increase the proportion of "foots" (an emulsion of water, dissolved lauric acid and coco-nut oil with fine meal in suspension) contained in the expressed oil, the removal of which is a frequent source of trouble and loss to the oil-miller.

Expression of Coco-nut Oil.

In the tropics, where coco-nut oil is the chief vegetable fat used, it is often expressed from the fresh nuts, or sometimes copra, by simple crushing in a pestle and mortar worked by a bullock team. Naturally, the percentage of yield of oil by this method is much less than when modern machinery is employed. However, in many important commercial centres in these countries, modern crushing mills, equipped with hydraulic presses, are now installed, and these mills supply the bulk of the oil for export and home consumption in the larger towns. In European crushing mills, most of the coco-nut oil is produced by means of hydraulic presses. The type usually adopted for materials of high oil content, such as copra, is known to the trade as the "cage" press.

An example of modern plant for the expression of coco-nut oil is represented by the Rose, Downs and Thompson "Premier" presses illustrated in Figure 5. In these presses several important labour-saving devices have been introduced, resulting in an increased capacity and very efficient operation. Each press is surmounted by a cooking kettle with an additional kettle, for the preliminary heating of the meal, on top. The kettles are steam-jacketed, 5 feet in diameter by 26 inches deep internally, and are made of cast-iron, lagged, and fitted with belt-driven stirrers and steam-damping apparatus. The presses each have an extracting box or pressing cage, 19 inches diameter by 9 feet long internally. The press head and base are of cast iron, the columns of forged steel; the hydraulic cylinder of cast steel with a ram of 18½ inches diameter, working up to a pressure of 3 tons per square inch. The presses are also fitted with preliminary compressor apparatus, automatic strickle, and hydraulic jacking cylinders. The latter comprise four small hydraulic cylinders in the press base, by means of which the press box can be lifted a distance of about 9 inches, the box being free to rise and fall in the press to this extent. In all Premier presses, the press box is free to rise and fall to a limited extent to facilitate the removal of the loose head block; in the earlier types of press, the box was lifted by skin friction between the box and the charge of meal, but with the jacking cylinders a positive lift is given to the box. When the hydraulic pressure is put on the press, the jacking cylinders are put in operation, and lift the box so that the loose head block enters the press-box to a depth of about 9 inches. When the main hydraulic pressure is released, the jacking cylinders are also allowed to exhaust, and they allow the box to drop gradually to its original position, acting meantime as shock absorbers. By this procedure, the risk of the loose head block being jammed by the expanding meal in the box is done away with.

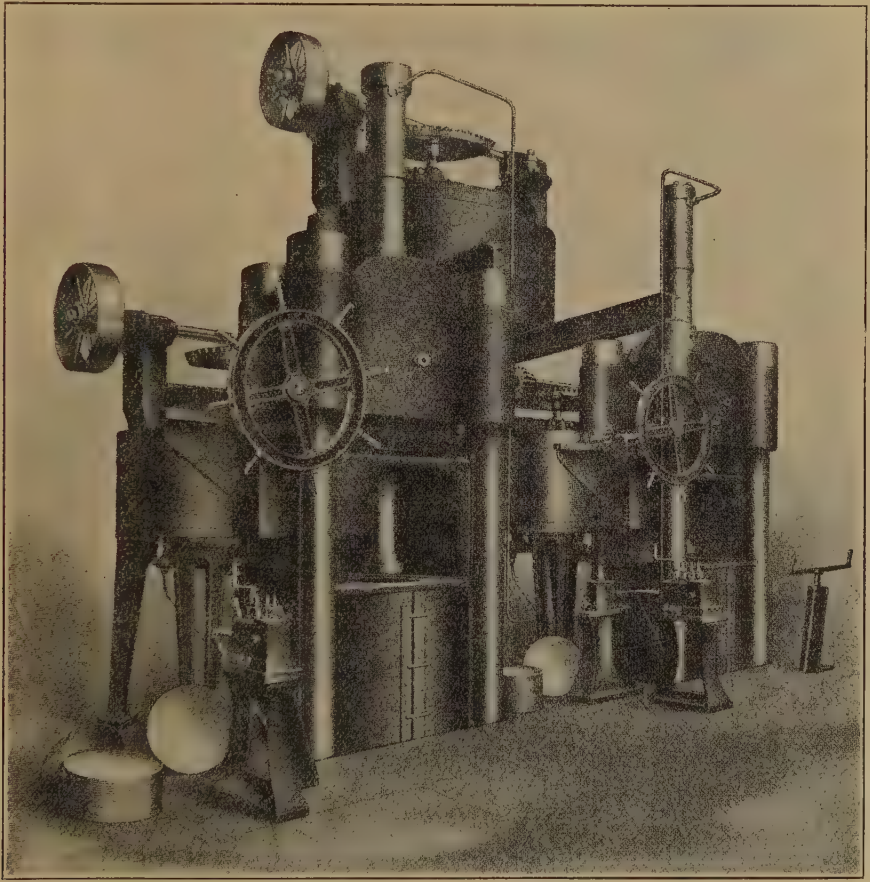

Fig. 5.—Copra Press.

Three cooking kettles are supplied with each pair of presses, the upper one serving for the preliminary warming up of the meal, or for the mixing of different grades of meal before crushing. From the upper kettle the meal passes, as required, to either of the lower kettles situated immediately above the presses. The heating up of the copra meal in the kettles facilitates the extraction of the oil in the presses; by this treatment, copra meal containing 70 per cent. of oil may be reduced, in one treatment, to 6 per cent. oil content. The meal may be heated in the cooking kettles to a temperature of 45 degrees to 60 degrees Centigrade, depending on the particle size of the meal and moisture content. Occasionally, copra meal is pressed in the cold; this produces a superior quality oil, but in much less quantity, and a cold pressing must always be followed by a hot pressing to reduce the oil in the residual meal to the appropriate amount. The extracting boxes of the presses are built up of steel staves, so constructed that when united they provide innumerable minute perforations, through which the oil may escape. The strain due to the great pressure employed is taken by a series of solid, weldless, steel rings which surround the boxes. To ensure even pressure throughout the charge in the press, steel plates, with an outer covering of softer material, are introduced into the press at regular intervals in the column of meal, during the loading operation.

The charging of the press is carried out automatically, as is also the levelling of the meal, both these operations being controlled by a foot-valve, thus speeding up the loading of the press and lightening the task of the operator. A hydraulic ram, operating from a compressor appliance at the top of the press, comes into operation several times during the charging of the press, packing the meal tightly into the press-box, and so greatly increasing the quantity of meal treated at one extraction. The hydraulic pressure employed in oil presses is as high as 6,000 lb. per square inch, and is obtained from a series of pumps, which, in the case of the larger mills, work in conjunction with high-and-low pressure accumulators.

The residual meal from the presses may contain from 5 per cent. to 9 per cent. of oil, and is valued as a cattle foodstuff chiefly for the oil it contains. The oil-miller often disposes of it to " compound " feeding cake makers, who incorporate it with other materials. In most oil-producing centres, the manufacture of compound cakes is quite an important industry, frequently carried on in factories quite apart from the oil mills.

Oil Expellers.

The Rosedowns expeller, illustrated in Figures 6 and 7, is a type of apparatus much favoured by small oil mills, or in isolated mills abroad, as no expensive hydraulic equipment is necessary. Heavy foundations are not required, and the expellers may be erected on any level floor or in an upper storey. In many oil mills they are used in conjunction with hydraulic presses, particularly in the treatment of meals of high oil content. In the case of copra two expressions are usually necessary when using the expeller; both expressions may be made in the expeller or one may be made in a hydraulic press. The oil is expressed from the meal in a split horizontal extracting box, or cage, made up of machined steel bars. A shaft running through the barrel carries a series of steel pressure screws affixed to it, which convey the meal through the box and at the same time exert a gradually increasing pressure. The oil is thus pressed out of the meal and escapes between the staves of the box. The residue or cake is discharged at the end of the box, through an annular opening. The meal is passed to the pressure screws by means of a feed worm which rotates over the worm shaft. Pressure exerted in the barrel on the meal may be adjusted by means of a sliding cone which reduces or enlarges the opening through which the cake is discharged. By engaging a clutch, the cone is moved mechanically, the limit of movement being fixed by adjustable catches which operate automatically. On the size of the annular opening allowed depends the amount of oil removed from the copra meal and the thickness of the leaves of cake discharged.

The treatment of the meal as regards grinding before it goes to the expeller is essentially the same as in other methods of oil extraction. For the necessary preliminary cooking a steam-jacketed heating and tempering conveyor is mounted over the standard machine. The meal is delivered to a feed receiver, which comprises a collecting and distributing pan, fitted with a stirrer driven by bevel gears from the worm shaft of the tempering trough. The purpose of this is to regulate the supply of meal to the tempering conveyor and thus ensure even feed

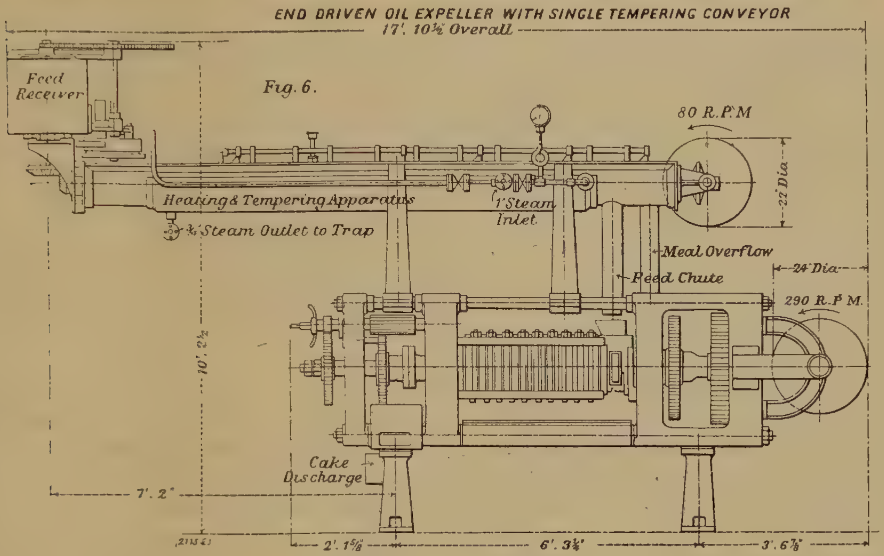
END DRIVEN OIL EXPELLER WITH SINGLE TEMPERING CONVEYOR
17'. 10¼" Overall
Feed Receiver
80 R.P.M
22" Dia
Heating & Tempering Apparatus
¾" Steam Outlet to Trap
1" Steam Inlet
Meal Overflow
Feed Chute
24" Dia
290 R.P.M.
10'. 2½
Cake Discharge
7'. 2"
2'. 1⅝
6'. 3¼"
3'. 6⅞"

Fig. 6.

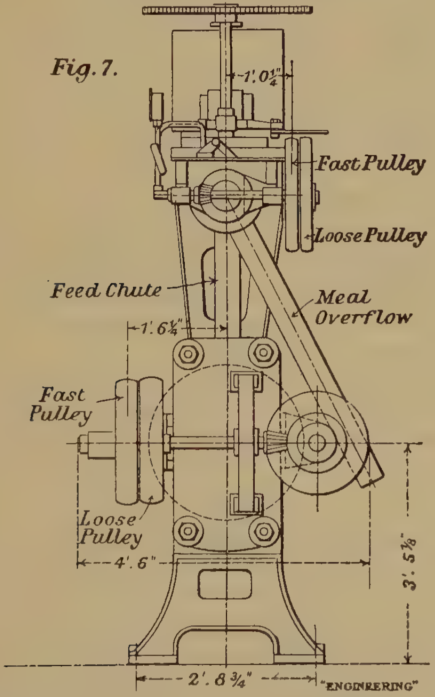
1'. 0¼"
Fast Pulley
Loose Pulley
Feed Chute
Meal Overflow
1'. 6¼"
Fast Pulley
Loose Pulley
4'. 6"
3'. 5⅞"
2'. 8¾"

Fig. 7.

"ENGINEERING"

to the expeller. Copra meal is passed along the trough by means of a screw conveyor, and is heated by the steam jacket. Live steam may also be admitted to the meal in cases where it is too dry.

The best yield of oil is only obtained when careful attention is given to the preliminary cooking of the meal. In the case of damp meal, surplus moisture must be evaporated off by means of the jacket steam, and no live steam admitted. Very dry meal may be sufficiently heated and damped by live steam alone. From the cooking conveyor the meal falls through a chute, fitted with a slide, into the barrel of the expeller, where it is passed to the pressure worms by means of the feed worm. An overflow chute is provided at the end of the tempering conveyor to pass over any surplus meal, which would be collected and returned to the feed receiver. The oil which is expressed drops from the barrel into a trough built into the machine just below the barrel. From here it can be led by a pipe into a ground tank from which it is pumped to store; or it can be run into an oil bogie or wheeled tank for transport to store.

In order to ensure freedom from trouble and automatic working, the Rosedowns expeller is well provided with self-acting safety devices. Mention has already been made of the clutch-operated pressure-regulating cone. This in itself acts as a safety device in the event of the machine being clogged. Should this occur, the clutch is thrown in and the cone automatically withdrawn, thus increasing the size of the annular orifice and allowing the cake freedom to pass. At the same time, by reason of the excess pressure in the barrel, the feed worm would cease to rotate, owing to the slipping of the friction clutch through which it is driven, independently of the pressure worm. Thus no more meal would be admitted to the box until the blockage is cleared and the excess pressure reduced. The surplus meal being passed along the tempering conveyor at such times passes out through the overflow chute. The barrel, which is built up of hardened steel bars, in a substantial cast-iron casing, heavily bolted, is readily opened for inspection or cleaning by the operation of a single lever. Owing to the extensive use of ball-bearings, the power required to work the expeller is low, and varies from 4½ horse-power to 9 horse-power, and the steam consumption generally does not exceed 70 lb. per hour. When the expressed coco-nut oil is intended for soap-making or other non-edible purposes, it is merely filter-pressed before being used; but if it is destined for edible use, it must pass through an elaborate purification process before it can be so employed. These purification plants or oil-refineries may be incorporated in the same mill in which the oil is expressed. In other cases they form entirely separate establishments, and may be situated at some considerable distance from the crushing mills.

Chief Applications of Coco-nut Oil.

In combination with other oils and fats, coco-nut oil is largely used in the manufacture of soap. The advantages of coco-nut oil to the soap industry are that it does not require bleaching before use; produces a hard soap which has, simultaneously, a fair degree of solubility in water; soap made from coco-nut oil will lather in salt water, an important consideration in the manufacture of marine soaps; the amount of glycerine produced in the making of soap from coco-nut oil is greater than can be obtained from any other oil available for the purpose. At the present time, coco-nut oil represents about 12 per cent. of the total oils and fats used in soap manufacture in Great Britain; and in America, about 20 per cent.

In the manufacture of margarine, coco-nut oil often plays an important part, comprising over 60 per cent. of the margarine in some instances. Its melting point, texture and consistency render it specially suitable for this purpose and result in a product closely simulating butter. Before the war, very little coco-nut oil was used in margarine making; the fats then employed were chiefly of animal origin. During the war and the subsequent inflation of prices for animal fats, coco-nut oil and other vegetable oils were employed in greatly increased amounts. Experience has proved them to be quite as satisfactory from every point of view, with the possible exception of their deficiency in vitamins. This deficiency is remedied in some cases during the manufacture of the margarine. During the last ten years or so, coco-nut oil has largely displaced cottonseed oil in the American margarine industry. It now represents nearly 50 per cent. of the total margarine made in that country, while in Great Britain the corresponding figure is about 35 per cent.

The "stearine" from coco-nut oil (obtained by pressing out the more liquid portion of the oil at a suitable temperature) is employed in chocolate manufacture to supplement the cocoa butter already present in the chocolate. Up to 5 per cent. of coco-nut oil is used in toffee manufacture. When the toffee is intended for export to tropical countries, hardened coco-nut oil is usually employed, as the higher melting point, about 41 degrees Centigrade, thus obtained prevents the softening of the toffee at the climatic temperature obtaining in such countries. Its keeping qualities render it specially suitable in the biscuit and similar foodstuffs industries.

(From *Engineering*, 16th October, 1931.)

STAINING WOODEN BENCHES BLACK.

Treatment renders benches so treated impervious to staining, and is acid proof. Used in chemical laboratories.

Solution 1—

105 grams anilin hydrochloride.
40 grams ammonium chloride.
720 grams water.

Solution 2—

105 grams copper sulphate, crystallized.
54 grams potassium chlorate.
720 grams water.

DIRECTIONS.

Apply Solution 1 thoroughly to bare wood and allow it to dry. Then apply Solution 2 and dry. Repeat these applications several times. Wash with plenty of hot soap solution, let dry and rub well with vaseline.

When finish begins to wear, an application of hot soap solution or vaseline will bring back the deep black colour.

GROWING IMPORTANCE OF SISAL INDUSTRY*

A few years ago people might have asked, "What is sisal?"

To-day, the commodity is much better known on account of the importance it has assumed among hard fibres, as they are called, to distinguish them from soft fibres obtained from the real hemp.

The uses of sisal are extending from binder twine for the reaper and binder to ply twines for parcels, cordage and ropes, and further into new fields such as attractive carpets, matting of varied gay hues and patterns. Australia uses a large quantity for plaster board, while for plastics sisal has been found to produce an economical and durable article which can be applied to many purposes. The tow and so-called waste find a ready market for upholstery, mattress filling, &c. It is also used for ladies' hats and footgear and for high-class paper. It can readily be seen that sisal, far from being unknown, may soon become a household word.

Sisal is a hardy plant and grows under varying conditions of soil and climate. Formerly, it was thought that it would only flourish in limestone soil near the coast, but its introduction in 1903 to the highland plateau of Kenya disposes of this theory. In that area, right on the Equator, a substantial production of excellent fibre is grown on rich soil at an altitude of 5/7,000 feet above sea-level, but the favourite area is the Usambara Province in Tanganyika Territory, with Tanga as its shipping port. In that district the Germans opened up the industry in 1893 and at the outbreak of the Great War the production had reached 20,000 tons. The ravages of war and the absence from the estates of the men in control reduced the production to 1,663 tons in 1920. Thereafter, the industry expanded rapidly and now constitutes the principal article of export from Tanganyika, with total shipments of 80,000 tons in 1937. In addition to the Tanga area, plantations are scattered at each side of the central line, which leads from Dar-es-Salaam to Lake Tanganyika, and in the south of the territory a flourishing industry has been established in the Lindi area, where labour is plentiful and the climatic conditions equally favorable.

Sisal is not a seasonal crop. It can be produced all the year round with a short break during the rainy season, which gives time for overhauling the machinery.

It is safe to estimate that capital has now been invested to the extent of about £15,000,000 for the sisal industry of British East Africa, which includes Tanganyika, Kenya, and to a small extent Nyasaland and Uganda. That there is room for expansion no one can deny, but it is of the utmost importance that there should be closer co-ordination between supply and demand so that the wide fluctuations in price which have so hampered the producer during the last few years shall be eliminated or greatly reduced; but sisal is fortunate in not being under any control of production, so that this fact, and the absence of stocks, maintain a liquid position which in the long run must bring about greater stability in the industry than is possible under the conditions involved in such controlled commodities as rubber.

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* From an address given by Mr. A. Wigglesworth at the Empire Exhibition, Glasgow, being one of a series on Colonial Empire Products arranged by the Colonial Empire Marketing Board.

Printed in Plantations Supplement to the *British Trade Journal and Export World*, October, 1938, Vol. LXXVI., No. 909, p. 19.

The users of sisal are constantly striving to promote improved quality of their manufactures. This entails a study of ways and means of supplying improved fibre. The close co-operation between the makers of spinning machinery and the research institutes is instrumental in securing far-reaching reforms and improvements in the fibre, so that it is now possible to spin it to 600 or 900 yards to the pound, in contrast to 170 to 200 yards, which was the best achievement when the fibre was less carefully prepared, and the machinery less efficient.

Latterly, a new type of plant has been discovered by the Amani Research Institute, which goes under the name of blue sisal, or botanically, *Agave amaniensis.* The leaf contains twice as many fibres, giving promise of a finer fibre which may lead to still finer yarns being spun. Investigations are now proceeding and the trade eagerly awaits the results of this interesting experiment. One problem in particular is receiving considerable attention at the present time. The decortication of the fibre produces under present conditions anything from 7 to 25 per cent. of waste fibre, which was formerly washed away and lost. Efforts are now being made to recover this lost fibre by submitting it to a process to prepare tow which can be used for filling mattresses, and in some cases for spinning. Recovery of this wastage will not only add to the output, but will correspondingly reduce the cost of the fibre, but it can only be done if prices are more remunerative than those now being paid.

Totalitarian countries are applying much skill, energy and capital to research on methods whereby they may convert one product into another, for instance, coal into "buna" or synthetic rubber, milk into textiles, &c., the cost is not considered. We, on the other hand, are concentrating on research to extend the utilization of certain products into new channels where they may be economically and profitably applied. There can be little doubt as to which system is likely to have greater permanence and to show more lasting economic benefits.

It is now clearly established that Africa, and principally East Africa, offers perhaps better advantages than any part of the world for the cultivation of this valuable fibre, which can be produced at a price which compares most favorably with the cost of competitive fibres such as Manila hemp from the Philippines; indeed, the Government of these islands has felt compelled recently to take steps to encourage improved conditions of their industry, by the constitution of a National Abaca Company, with a capital of about £2,000,000. East Africa, however, is not afraid of this competition, and under the stimulus of admirable research work the organization of the industry may be considered more up to date than that of any fibre industry.

[EDITORIAL NOTE.—Under the Papua and New Guinea Bounties Act of 1937, a bounty of £6 a ton is payable to producers of sisal and planters might well give consideration to sisal as a crop. Good stock material is available on application to the Department.]

UPLAND RICE.*

Upland or hill rice does not differ botanically from swamp rice. It does, however, require different climate and soil conditions. Swamp rice has to be grown in water for the greater period of growth, whereas this is unnecessary in the case of upland rice.

It should not be thought, however, that any kind of rice is a suitable crop for areas lacking in water. A crop of upland rice needs at least as much water as one of corn, and more than guinea corn. Rice also likes a fairly high temperature and a clay loam soil, though it will grow on lighter and more open soils provided the water supply in such soils is maintained.

Upland rice is planted in a similar manner to corn; the land is ploughed or forked in the usual way and the seed is sown broadcast, or drilled in rows of 2 to 3 feet apart, the seeds being 6 inches to 1 foot apart in the row. These spacings may be altered to suit conditions of high or low fertility. About 30--40 lb. of seed will plant an acre, depending on the variety and size of grain and various other conditions of planting. Cultivation is usually confined to two weedings, which should take place while the plants are small. Cultivation by means of animal drawn implements can only be carried out if the crop is planted in rows. Once properly established, the plants produce numerous tillers or suckers, and form a dense cover effectively preventing the growth of weeds.

The grain is borne in heads produced at the end of the stalks. With most varieties, the grain ripens in about a month after the heads have shot.

The crop period varies with the variety, but about six months is the average. Planting usually takes place at the beginning of the rainy season and the crop is reaped some six months later.

Reaping is done with sickle, the straw with the heads attached being made up into bundles for transport. Reaping should be done when the average head is ripe; as if the crop is left until all heads are ripe, there will be considerable loss due to "shattering", i.e., dropping of the grain. The bundles are usually dried for a few days before threshing.

The grain is removed from the head by beating against wooden trestles or by treading with animals; when still enclosed in the husk it is known as "paddy". The paddy is then winnowed in order to remove pieces of trash, &c. The grain has to be freed from husk. This can be done on a small scale in hand-mortars, but it is laborious business and results in a high percentage of broken grains. Small hand mills are now available for doing this work. Modern milling machinery removes the husk and the cuticle or skin and then polishes the grain. The result is "polished rice", which is the kind commonly sold in Jamaica. The embryo or germ is removed during milling, and the bran is a useful fodder, being high in protein and fat. The polished rice is, for this reason, a poorer food than the "brown rice", obtained by husking without polishing. The use of polished rice as the main food sometimes causes a deficiency disease known as "beri-beri", which disappears when brown rice is substituted. In British Guiana the grain is parboiled before milling, i.e., soaked in water, drained and steam is then blown through it. This not only makes milling easier, but reduces the percentage of broken grains, and also produces a more nutritious rice.

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* By J. M. McEwen, D.I.C.T.A., in the *Journal of the Jamaica Agricultural Society*, Vol. XLII., No. 6. June, 1938.

A fairly large amount of upland rice was grown in Jamaica during the war, and several articles on the subject are to be found in the *Journal of the Agricultural Society* for 1917 and 1918. The chief difficulty appears to have been that there was no machinery for milling the grain after it was produced, as in those days the small mills mentioned above were not available. Most of the cultivation was in Clarendon and St. Andrew. Yields of 40 bushels of paddy were recorded, though it is doubtful whether the average was over 25–30 bushels per acre. Twenty-five bushels of paddy should give from 15–17 bushels of milled and polished rice. The straw is useful litter for stables, and makes good synthetic farm-yard manure.

The number of distinct varieties is very large, and it is important that the suitability of a variety to local conditions should be determined by field tests before any extensive planting is made. In countries where rice growing is an important industry, it is customary for the Department of Agriculture to maintain stations for this purpose, and also to provide pure seed. Seed selection is of great importance, as bad characteristics, such as shattering or weakness of stalk, will cause considerable losses in fields grown from unselected seed.

SILVERFISH BOOK VARNISH.

Inquiries are often made for a preparation that can be painted over the covers of books to prevent damage by silverfish and cockroaches.

The following mixture has been tried successfully over a number of years both in tropical and temperate regions with consistent success:—

Shellac	½ oz.	or	10 grams.
Creosote	2 drahms	or	5 c.c.
Methylated spirit	8 oz.	or	160 c.c.

It is advisable to break the shellac up fairly small as it is slow to dissolve. Mix the ingredients together in a bottle larger than required for the volume, and keep shaking.

This varnish is painted over the covers and it is not sticky when dry, and gives a dull surface; it will, unfortunately, dull gold lettering on bindings.

THE SOLAR FERMENTARY FOR CURING SMALL QUANTITIES OF CACAO.

(Circular prepared by Dr. F. J. Pound, Department of Agriculture, for distribution to peasant proprietors and small estates.)

This method for curing small quantities of cacao has recently been perfected at the Imperial College of Tropical Agriculture by Professor Hardy and Mr. J. A. MacDonald and a detailed account of the process is printed in *Tropical Agriculture,* Vol. XIII., No. 7, pp. 171-174. Extracts from this paper are reproduced below:—

" Cacao produced by peasant proprietors accounts for approximately two-thirds of the world's total production, and this enormous quantity of cacao, in the neighbourhood of 350,000 tons annually, has all the faults of cacao fermented in separate small quantities. Thus, peasants' cacao is recognized by manufacturers to be of inferior quality and lower value than estates' cacao, the lower quality being in large measure due to the inferior methods of preparation employed by small holders. In this article a new fermentation method is described with which it is possible to ferment separate small quantities of cacao so that *the final product is equal in appearance and value to estates fermented cacao.*

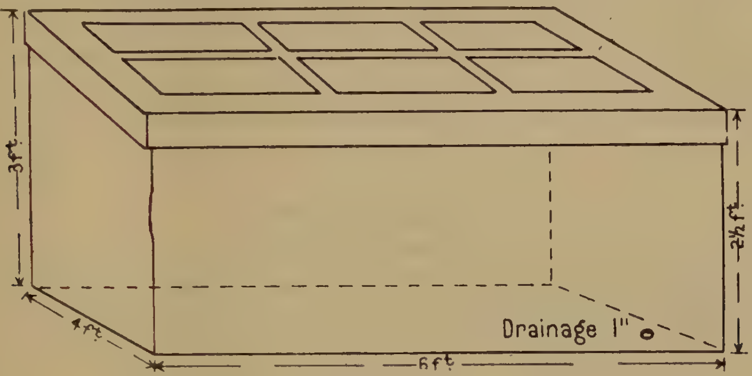
" A single picking on a small property may often amount to no more than fifty pounds to one hundred pounds of wet cacao, and the practical difficulties of obtaining a satisfactory product, when such small lots of cacao are fermented by the usual methods, are well recognized. The trouble arises through the large area of surface exposed in relation to the volume of the mass of cacao beans so that too great loss of heat occurs. The high temperatures requisite for killing the embryo of the bean are therefore never attained, and the internal changes associated with proper fermentation do not take place or are incomplete. A small bulk of cacao is also apt to dry out too quickly. In an endeavour to increase the quantity of cacao available for fermentation, the small holder usually picks his cacao only at long intervals and includes unripe and overripe pods in his picking. The net result of all these adverse factors is that the majority of the beans are unfermented or only partially fermented, some are germinated, and those occurring at the edges are dried up and shrivelled, or may be covered with obnoxious and unsightly moulds. Peasants' cacao is therefore recognized by the manufacturers to be of poorer quality and lower value than estates' cacao.

" The crux of the fermentation problem appears to be the protection of small quantities of cacao from excessive evaporation and cooling. If this can be done effectively and cheaply, then there is no reason why a good quality product should not be obtained by the ordinary method of natural fermentation which has proved satisfactory with large quantities under estate conditions."

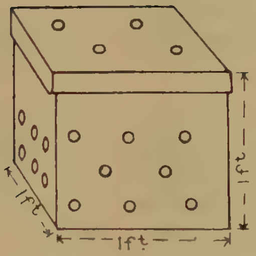
What is the Solar Fermentary?

The solar fermentary is essentially a large box with thick walls to prevent escape of heat and a glass lid to trap the sun's rays. Inside this large box are placed small covered boxes filled with cacao beans with an adequate supply of water to keep the whole of the interior very humid. The small boxes of cacao may contain as little as 50 lb. of wet beans and several such boxes may be used at the same time inside the large box, The first solar fermentaries were made of wood, 6 feet long, 4 feet wide and 3–4 feet high with double walls giving a 3-inch air space. The space between the walls may be packed with dry straw or coco-nut fibre to give better insulation.

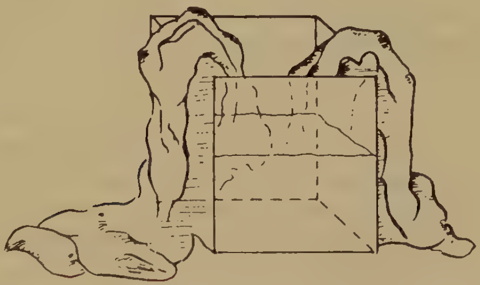
Other boxes have been constructed of tapia, using wood only for the corner posts and sills. The glass top is now made slanting to drain off water more easily and is hinged at the back for easy opening. The floor of the solar fermentary may consist of only rough stones if desired but a wood floor with spaces for drainage is better if it can be included.



The Solar Fermentary for curing small quantities of Cacao



Drainage and aeration holes also in base and lid



Pitch Oil tin, Water and Wick

The small boxes may conveniently be made as illustrated with sides about 1 foot pierced with drainage holes and lined with banana leaves before filling with cacao beans. It is very important that the supply of water is included and a pitch-oil tin with sacking wick is quite satisfactory for this purpose. If the inside of the fermentary is painted black this gives additional advantages.

The solar fermentary must be built in an open space so that it gets all the heat possible from the sun's rays. There is no need to turn the beans or even to open the lid of the fermentary once it is in operation although for the purpose of inserting another box of beans, opening for a few seconds will not do any harm.

Fermenting should be continued for six days uninterrupted,

Reports.

All the reports received for cacao fermented in this way, whether it is estates' cacao or peasant proprietors', have been thoroughly satisfactory and several brokers and manufacturers place the solar fermentary product in a class above normal Trinidad plantation grade. If a peasant proprietor who at present has no adequate fermenting facilities wishes to build one of these solar fermentaries he can do so using his own labour for a cost of $5.00 or $6.00. The glass top is the only expensive item. There will then be no reason why he should not receive top market prices for his product if he carefully follows the instructions given above. A difference of only 1 cent per lb. for properly cured cacao would soon repay the cost of the fermentary.

Here are quotations of some of the samples of solar fermentary cacao submitted to Port-of-Spain dealers and European brokers for reports—

A.—Port-of-Spain Reports.

"The dealers' reports show that small lots of 40 lb. to 60 lb. wet cacao could be successfully fermented in a wooden sweat-box enclosed in the solar fermenting frame. The final product of 15 lb. to 23 lb. dried, cured cacao beans was better fermented, had a better external and internal appearance, and higher value on the local market, than cacao fermented in large batches (2,000 lb. to 4,000 lb. wet weight) under the ordinary estate conditions obtained in Trinidad. The solar fermenting frame seemed to be very effective in producing an even fermentation throughout this small mass of cacao. The surface layers were free from mould, and as well fermented as the central portion. This is in direct contrast to the results obtained with small lots of cacao fermented under ordinary conditions. The low value of these samples was largely due to the inferior quality of the surface layers, which either became mouldy or dried and shrivelled during the fermentation process."

B.—European Reports.

1. "Both samples were well up to the standard of good quality Trinidad in the raw bean and there is no special criticism to make of the break."
2. "If the sample is intended as a test of the quality that can be prepared by the solar fermentation system for small quantities of cacao, the experiment may be regarded as very successful."

A FORMULA FOR MEASURING RAINFALL.

Pour the rain into any graduated glass—such as an apothecary's glass—the exact capacity of which is known either in cubic inches or fluid ounces. If the measure gives fluid ounces, reduce these to cubic inches by multiplying by 1.733. Then the formula for reduction is: $R = A$ upon $3.1416 \times O2$. Where R is the rainfall in inches, A the number of cubic inches of rain in the glass, and O the semi-diameter of the funnel in inches, R should then agree with the amount shown by the graduated glass supplied with the gauge.

SOIL FERTILITY, NUTRITION AND HEALTH.*

(By Sir Albert Howard, C.I.E., M.A., formerly Director of the Institute of Plant Industry, Indore, Central India, and Agricultural Adviser to States in Central India and Rajputana. Reprinted from "Chemistry and Industry," by kind permission of the Society of Chemical Industry.)

In order fully to apprehend our subject, it is necessary to look back nearly 100 years and pass briefly in review the great industrial era of the nineteenth century, making the development of agricultural science and practice during that period of remarkable material prosperity and suggesting wherein it has proved inadequate to ride the storm in which those years culminated—a storm as unforeseen as it has proved disastrous to agriculture.

In the year 1840 Liebig published his celebrated essay entitled "Chemistry in its Applications to Agriculture and Physiology," embodying his well-known mineral theory on the substances found in the ashes of crops. Up to this time, the fertility of the soil had been maintained by means of some form of organic matter, such as farmyard manure, supplemented by suitable crop rotations, including fallows; the accepted view that soil required humus was unchallenged. From 1843 onwards experimental theory centred in the new thought advanced by Liebig; the idea that stimulation must of necessity mean progress gained credence in an age when progress was the watchword; soil chemistry, as we know it to-day, was born. With the further development of the Liebig tradition at Rothamsted and elsewhere, came steady progress in the manufacture and use of artificial manures. After the Great War, when the factories engaged in the fixation of atmospheric nitrogen for the manufacture of explosives had to find other markets, the use of nitrogenous fertilizers in agriculture increased, until to-day the majority of farmers and market gardeners in this country base their manurial programme wholly on the cheapest forms of nitrogen, phosphates, and potash on the market. What may be conveniently described as the NPK mentality dominates farming practice alike in the experimental station and the countryside. Vested interests entrenched in time of national emergency have gained a stranglehold.

What has been happening to the land during these 100 years? For a time all seemed to be well and agriculture shared in the general prosperity. Just as soon, however, as the original store of humus, which is found in all fertile soils, began to diminish a number of subtle changes made their appearance. Insect and fungous diseases increased and it became necessary to combat these with poison sprays; animal diseases are now rife. Deeper and more extensive cultivation became a necessity and increase in production was the only goal. Old-time tests such as taste and quality in produce were abandoned, and at a moment when, had they been applied, they would have shown clearly in what direction chemical manures were leading us. For artificial manuring leads tortuously to artificial demand, and it has not been enough that we should regulate production to demand. Agricultural policy must achieve a definite goal, and that goal is neither the economic necessity of the hour nor yet the building up of emergency reserves—it is the health of the nation.

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* From *The Planters' Chronicle*, 11th June 1938.

The species of account that Mother Earth is likely, sooner or later, to present to those who misuse her resources may be examined in the United States of America. There the vast heritage of reserve fertility created in the past by the forest and the prairie has been used up to produce the large and ever-increasing quantities of food and raw materials needed by the urban populations engaged in commerce. The early settlers proceeded to cash in their humus mine and had no thought but to get rich quickly. The whole subject of soil fertility remained unexplored; such questions as the correct balance between animals and crops did not arise. Large crops were obtained without manure of any kind and while the original store of organic matter lasted all appeared to go well. To-day the bill is in the hands of the American people and their Government. In 1935, an eminent American engineer uttered a solemn warning that if the soil were to be continuously squandered, as then, the country might expect "less than a hundred years of virile national existence".

Over vast areas of the country the loss of organic matter has been followed by the destruction of the crumb structure; the compound soil particle has lost an essential constituent—the cement provided by humus. In the drier wheat areas, like Dakota, farms are blowing away; the deserts are on the march. In the tract drained by the Mississippi River the destruction of the crumb structure has been followed by loss of soil permeability to such an extent that the land is unable to drink in the rainfall and extensive erosion has been the inevitable result. It has been stated that the denuded areas approach in size all cultivated Germany. Over-stocking, over-cropping, over-stimulation, the wholesale destruction of timber—these are the malpractices which destroy fertility.

The lessons taught by the middle west and by the prairie provinces of Canada, where agriculture has collapsed with such dramatic suddenness, are being repeated in certain areas of this country which have been regularly manured with artificials only. Both the North American and the British methods of crop production have shown themselves to be lacking in the one thing that matters in agriculture—permanency.

Let us examine a system that will pass the test of permanency; let us turn to China, where the system of agriculture is at least 4,000 years old, and note the major respect in which it differs from our own. In China the processes of decay invariably receive as much attention as the processes of growth. Every possible kind of waste—vegetable, animal, and human—is carefully collected and put back into the soil. Animal residues, and more especially urine, are utilized to the full. This has been done for 40 centuries, and Chinese agriculture presents the one unanswerable argument in its favour—success. The soil has continued to maintain a dense population without the importation of food from other countries; the good earth is handed on as a great possession from one generation to another. We have here a remarkable example of practice anticipating theory.

The striking contrast between the failure of western science to maintain soil fertility and the success of the methods followed by the peasants of China was one of the factors which gave rise to the Indore process for the conversion of vegetable and animal wastes into humus. The immediate consideration, however, was the need for increasing the fertility of the soil of India in order that improved varieties of crops might come into their own. The introduction of improved varieties by themselves yielded only a small increment; the combination of improved varieties plus improved soil conditions doubled the crop and left the land in good condition.

The Indore process is simple. A layer about 6 inches deep of mixed vegetable wastes is lightly covered with about 2 inches of farmyard manure followed by a good sprinkling of earth. If any wood ashes are available these are added with the soil. The proportion of mixed wastes to farmyard manure must not exceed 3:1 by volume. The sandwich process is repeated until the material in the heap or pit is after fermentation 3 feet thick. The layers must be kept moist, but not wet, lest the air supply be interrupted. The moistened heap should resemble, as far as possible, a pressed-out sponge. The temperature rapidly rises to about 150 degrees Fahrenheit and the whole mass becomes covered with greyish-white mycelium. After two or three weeks the heaps or pits are turned and watered if necessary. A second turn and watering follows at the end of six weeks from the start, by which time the mass has crumbled and turned black. In three months from the beginning the carbon:nitrogen ratio falls from 33:1 in the original mixture to about 12:1, when the humus, which resembles old leaf mould, is ready for the land.

Over-acidity, faulty aeration, too much moisture, or an unsuitable site—any of these may present a passing problem in this country. Such problems must be tackled bearing in mind the special circumstances giving rise to them. In no case yet have they proved insoluble.

The process is a partial reversal of the work of the green leaf. In the cells of the leaf simple substances obtained from the soil and the atmosphere are synthesized by means of the energy of sunlight into carbohydrates and proteids. The fungi and bacteria in the compost heap practically undo this synthesis until a comparatively stable condition of organic matter is reached in the shape of humus. This is the real food of the soil and of the crop. The second stage in breaking down the materials made by the leaf is only reached when the soil organisms oxidize humus into simple substances once more which can be absorbed by the roots of plants. The wheel of life has then completed a single revolution.

It is not difficult to understand that the use of artificials in feeding the crop direct side-tracks a portion of Nature's essential round; artificial stimulus applied year after year, and at the same time, must inevitably breed evils, the full extent of which are as yet dimly seen. The relation between quality and yield, for example, does not lend itself to scientific formulae. The time may come when yield will depend entirely upon quality, but quality can never under any circumstances depend upon yield. Factory-made manure is the weak link in the chain of agricultural economics.

In devising the Indore process the various methods of dealing with soil fertility all over the world were naturally studied, as well as the work of the experimental stations in manuring, from the time of Liebig onwards. The result was illuminating. The practice of the peasants in China—the Farmers of Forty Centuries—suggested the desirability of making the fullest use of every form of vegetable and animal waste. Most of the research work underlying the Indore process was found scattered through the literature, very much as materials lie about in a builder's yard before the building is erected. Everywhere fragments of a larger question were to be found. The nearest approach to the Indore process was made by Rothamsted, where, however, the investigators made two fatal mistakes: (1) the use of chemicals instead of urine as an activator in breaking down vegetable wastes, and (2) the patenting of the ADCO process. Urine consists of the drainage of every cell and every gland of the animal body and contains not only everything needed by the fungi and bacteria which makes humus, but all the accessory growth substances as well. ADCO merely supplies nitrogen and minerals as well as lime—a far inferior base to the wood ashes and soil used in the Indore process. It focuses attention on yield rather than on quality. Further, the patenting of a process always places an investigator in bondage; he becomes a slave to his own scheme. Progress then becomes difficult, or even impossible.

The adoption of the Indore process all over the world has been very rapid. Thanks to the help of Major Grogan, D.S.O., and Sir Milsom Rees, G.C.V.O., practically every coffee estate in Kenya and Tanganyika had adopted the method by the end of 1933. Tea, sugar, sisal, cotton, coco-nuts, maize, and other large-scale industries soon followed. In 1935, a beginning was made in Great Britain, where now a number of estates, farms, and market gardens are busy converting all their wastes into humus. Some of the experimental stations in this country have followed the lead of the live wires in the farming community.

The Indore process has already outgrown its early beginnings. The underlying principles have enabled the problem of green-manuring to be solved; an uncertain method of enriching the soil has been converted into something which can be relied upon. This development was worked out during the last two years on the potato areas of South Lincolnshire which have begun to suffer from a shortage of humus. After the pea crop—grown for canning—has been harvested, the land is immediately drilled with beans. The sown area is then covered with a layer of crushed straw from the shelling machines followed by a thin layer of farmyard manure. The Indore process then sets in on the surface of the soil. The beans grow through the fermenting mass and at the end of September are ploughed in with the layer of finished compost. Decay is rapid and by the time the fields are planted in potatoes the following spring the resulting humus has been incorporated in the soil and is ready for nitrification. This modification is known as sheet composting—the making of humus in a thin layer all over the surface. Catch crops of beans or mustard or a crop of weeds can also be manured with humus, or a farmyard manure, before plough-in in the autumn, when sheet composting again takes place. The turf of old pastures or old leys can be converted into humus in a similar fashion. The Indore process has in this way been applied with success to no less than three important practical problems—green-manuring, the effective utilization of weeds and stubble, and the better utilization of the old turf of grassland.

Another important development has also taken place. In India, Ceylon, and Africa, town waste and night soil are now being converted into humus by the Indore process. In some cases, as in Nairobi, the production of humus from town wastes is being carried out on a commercial scale and Humetco—the trade name for the compost—has been on the market for some time. In Great Britain developments are taking place in the same direction. Dust-bin refuse is being used on a large scale as a constituent in the compost heaps for such crops as fruit and hops, and also in ordinary farming practice.

The adoption of the Indore process is not confined to the British Empire. Some of the papers describing the method have already been translated into German and Spanish, and I believe a Danish version is in process of preparation.

The most important development of the Indore process in Great Britain concerns the proper use of dustbin refuse, of seaweed, and of the vast stores of organic matter in the old turf of grassland. As is well known, the contents of the dustbin in this country are either buried or burned. Very little finds its way back to the land. Yet this material is exactly what is wanted in the compost heap in a country like Great Britain, where so much green waste (which is liable to pack in the heaps) is available, and where the total volume of plant residues is not so great as in the tropics. Town wastes perform two useful functions: (1) they help to aerate the heaps and to absorb the surplus rainfall, and (2) they increase the volume of the resulting humus.

The harvest of the sea is now only imperfectly reaped in the form of fish. Much of this harvest—the seaweed thrown up on the shore—is still largely wasted, although it is perhaps the most effective constituent of a compost heap that occurs in this country. A few examples are needed in which the seaweed brought in by the tide is composted with the municipal wastes of seaside towns, the resulting humus being used for intensive vegetable growing. A suitable beginning might be made at Worthing, in Sussex, where large quantities of seaweed are thrown up on the beach and where no agricultural use is made of the wastes of the town.

The proper utilization of the organic matter in the turf of pastures and leys is now one of the chief items on the programme of the Welsh Plant Breeding Station at Aberystwyth. Professor Stapledon is constantly urging the ploughing up and re-seeding of grassland, which, of course, involves the manufacture of humus in the surface soil. Another similar application of the Indore process is the system of milking-bails devised by Mr. Hosier on the chalk downs of Wiltshire.

It is a fact that British agriculture does not supply one-half the total food consumed. Common sense, therefore, dictates that those articles of diet in which supreme freshness is (or should be) the sole criterion of their true nutritive value should be home-grown. This means intensive cultivation (and incidentally a high rate of employment); it means also improvement and indeed curtailment of those 16,000,000 acres of permanent pastures in England and Wales, which Professor Stapledon once confessed in public made him "see red"; it means increasing livestock; and it means all this in the national interest. Now the conversion of agricultural and municipal wastes into humus for increasing the fertility of the soil has a direct bearing on health. It will in all probability be the means by which a new forward move in preventive medicine can be initiated. There exists to-day a considerable body of evidence which supports the view that the fertility which follows the regular application of humus is the surest foundation upon which to build the health of a nation. There is undeniably a close connexion between quality and health, but it defies analysis. The word "bloom" subtly suggests both. Quality in produce, although difficult to define, is saleable.

In the case of the wheat crop raised on Viscount Lymington's estates in Hampshire, careful records have been kept of the life of wheat straw when used for thatching. Wheat straw from fields manured with organic matter, partly of animal origin, lasts ten years as thatch; straw from similar land manured with artificials last five years. What the difference in quality is between the two sets of grain has not yet been determined. In Worcestershire experienced merchants are convinced that the highest quality crops are always produced with farmyard manure.

In vegetable growing the effect of organic manuring quality can be seen on a large scale on Mr. Secrett's farm on Walton-on-Thames. Mr. Secrett uses practically no artificials and raises his produce on fermented stable manure. He stands at the head of his profession as regards quality.

At the Iceni Nurseries at Surfleet, Captain Wilson has been converting all waste products into humus by the Indore process since November, 1935. The result has been amazing as regards the improvement in quality. Further, in a memorandum to members of the British Association visiting his estate on 4th September, 1937, Captain Wilson states—

"The method of humus-making which has been employed is known as "The Indore Process" and it has proved remarkably successful. The output in 1936 amounted to approximately 700 tons and in the current year will probably be about 1,000 tons.

"As a result of this utilization of humus the land under intensive cultivation, has already reached a state of independence, and for the last two years no chemicals have been used in the gardens at all either as fertilizers or as sprays for disease and pest control. The only wash which has been used on the fruit trees is one application each winter of lime sulphur, and it is hoped to eliminate this before long."

In Madras, McCarrison found that grain produced with farmyard manure contained more vitamins than that grown with minerals. In a recent lecture at the Royal Institution, this investigator summed up his long experience on nutrition as follows:— .

"What I want you to learn from this lecture is that it is the foodstuffs themselves that matter to you, rather than any chemical ingredient of them. These when properly combined in the diet, supply all the food essentials, known and unknown, discovered or undiscovered, needed for normal nutrition, provided they are produced on soils which are not impoverished. For if they be produced on impoverished soils their quality will be poor and the health of those who eat them—man and his domestic animals—will suffer accordingly. Man is literally created out of the earth, since it is the earth that supplies, through the agency of plants, materials out of which he is made. If, therefore, he is to derive all the benefits which the earth is so ready to yield to him he must employ his intelligence, his knowledge, and his labour in rendering it fit to yield them to him. In this country impoverishment of the soil goes on apace because we take out of it in the form of crops more than we put into it in the form of animal and other organic manures. This impoverishment leads to infertility of the soil and this, in its turn, to a whole train of evils; pasture of poor quality; poor quality of the stock raised upon it; poor quality of the foods this stock provides for man—meat, eggs, milk; poor quality of the vegetable foods he raises for himself; and faulty nutrition with resultant disease in plants, beasts and man. Out of the earth are we and the plants and animals that feed us created and made, and to the earth we must return the things whereof we are made, if it is to yield again foods of a quality suited to our needs."

The evidence in favour of the view that disease resistance in plants and animals depends on soil fertility is also considerable.

My own experience in India from 1905 to 1931, is summed up in a paper on the "Role of Insects and Fungi in Agriculture," published in *The Empire Cotton Growing Review,* XIII, July, 1936, p. 191. I have had no reason to alter this opinion; rather my conviction as to its truth has strengthened. I said then—

"Insects and fungi are not the real cause of plant diseases, and only attack unsuitable varieties or crops improperly grown. Their true role in agriculture is that of censors for pointing out the crops which are imperfectly nourished. Disease resistance seems to be the natural reward of healthy and well-nourished protoplasm. The first step is to make the soil live by seeing that the supply of humus is maintained."

The most striking confirmation of my views has been supplied by commercial vegetable growers all over the country who use humus only for growing their products.

In regard to animal diseases, my experience in India was very similar. From 1910 onwards, I was allowed to have my own oxen at Pusa, Quetta, and Indore, and I made full use of these animals for the study of disease. The greatest care was taken in the selection of the breed and of the type of animal; the feeding, hygiene, and management was as near perfection as I could make them. For twenty-one years—1910 to 1931—I was able to study the reaction of well-fed animals to the epidemic diseases such as rinderpest, foot and mouth disease, septicaemia, and so forth, which frequently devastated the countryside. None of my animals were segregated; none were inoculated; they frequently came in contact with diseased stock. No case of infectious disease occurred. The reward of well-nourished protoplasm was a very high degree of disease resistance, which might even be described as immunity.

A simple explanation of the results described in the last portion of this article is that a fertile soil enables the green leaf to carry out the synthesis of carbohydrates and proteids in an effective manner. Two important results then follow:—(1) insects and fungi find such crops unpalatable, and (2) the organisms which are associated with the diseases of animals fail to flourish. The energy of sunlight through the agency of a fertile soil can therefore be effectively transmitted, first to the plant and then to the animal. It follows from these results that there must be a common baseline—soil fertility—in all future work connected with nutrition. If this is not ensured confusion and uncertainty will result. The research structure must above all things, have a firm foundation; the results obtained in the various countries and at the various centres must be comparable. It will not be sufficient in the future to work on material of varying nutritive value. In the past investigators have used such produce as existed; they have rarely grown their experimentl material on really fertile soil and based their experiments on the very best produce Nature can provide; the agricultural basis of much of the reasearch structure is therefore faulty.

Research upon the lines I suggest pre-supposes, of course, a conscious and deliberate forward policy in agriculture, based upon land in good heart and vigorously pursued in perhaps the greatest of all national interests—health.

PYRETHRUM IN KENYA.*

(*V. A. Beckley.*)

Although the industry is only five years old, Kenya pyrethrum is now established on the market and with a good reputation. This rapid progress is attributed in great part to the close co-operation between planters and the Department of Agriculture. Cultural and other notes of general interest include the following: Pyrethrum (*Chrysanthemum cinerariaefolium*) requires a deep, well-drained soil; it is intolerant of too rich or even slightly water-logged soils. When required in great quantity, plants still have to be raised from seed. Nevertheless, the plant is easily raised from cuttings or division and the life of the plantation is not shortened thereby—in spite of the contrary opinion held in other pyrethrum growing countries. The vegetatively propagated plants are altogether easier to handle than seedlings and flower sooner. In Kenya, the plant is self-sterile, so that too rigorous a selection must not be practised, another reason against stringent selection being the variability of pyrethrin content between strains which show no outward sign of difference. The theoretically optimum time for picking is when the last florets are about to open. This is impossible commercially. In Kenya, where the flowering period is continuous for ten months, a plant will bear flowers in all stages of development. Various adjustments of picking periods and methods are adopted to secure a good average of mature flowers and the length between the former is largely dependent on the climatic conditions associated with increasing altitude; thus, at 6,000 feet in warm weather, opening may take nine days, whereas, at 9,500 feet in cool weather, it may take three weeks. The daily task for an average picker is 30 lb. The annual yield varies with altitude from 4 cwt. per acre at 5,500 feet to 10–15 cwt. at 9,500 feet. Much remains to be learned about the response of the plant to climate in growth, flowering and pyrethrin content. Just before passing into a resting season with the dry weather, the plants are cut back, originally to remove dry flower stalks which interfere with picking, but now also because a definite degree of pruning appears necessary to maintain the plants in good production. Pyrethrin content appears to diminish as the flush ages and probably with age of plant also, but evidence at present is contradictory. At present, the profitable life of a plantation, usually 4–6 years, is only terminated by depression of yield through weed growth. Since, in drying, a fresh flower loses 75 per cent. of its weight and the climate is often moist, artificial drying is necessary and a suitable dryer capable of local construction has been evolved. The principle of this is an upward draught of air heated by passing over a flue system, which is forced through a series of trays containing the flowers. Attention to certain details which are described ensures in this dryer a very attractive sample with the natural colour of the flowers unaffected. Methods of grading, sampling and baling are briefly described.

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* From I.A.B. Imperial Bureau of Horticulture and Plantation Crops—Horticultural Abstracts. Vol. VIII., No. 2, Abs. 462, June, 1938.

(An abstract from Bulletin, Imperial Institute, London, 1938, 36 : 31–44, bibl, 7.)

THE SALAD WAY TO HEALTH.*

(*Miss G. L. Roberts* (*Narridy*).)

A special feature of scientific eating is making the right use of fresh, uncooked vegetables and fruits in the form of salads. The blood-stream of man contains sixteen chemicals, and these chemicals are the absolutely necessary substances for keeping and renewing health. "The blood is the life," and unless the blood is furnished with the right materials in the right quantities, the body will suffer in some way.

A free use of salads will purify the blood and restore tone to the system. A green salad should form the chief dish of one meal every day. The advantages of raw food are that it prevents quick eating, ensures an ample supply of vitamins. and stops excessive seasoning and the use of superheated fat.

To Prepare Lettuce for Salads.

Salads can be the most tempting of dishes, or the reverse, according to the way the "greens" are prepared. A little extra trouble taken with these makes all the difference between resignation to the salad course or relish of it. Pull off the outside leaves of the lettuce, then wash quickly. Dry the lettuce thoroughly; break it with the fingers; do not cut it. Use the best olive oil and lemon juice.

Dressing the Salad.

Mix a little salt (vegetable salt for preference) with a spoonful of lemon juice and sprinkle evenly over the lettuce, turning it all the time to get it evenly coated. Then sprinkle the oil in the same way. Do this immediately before serving. A salad is spoiled if left standing. Rubbing the bowl it is served in with a cut onion gives a pleasant flavour. This is a plain dressing with oil and lemon only. When other dressings are used, serve them separately in small jugs. Salads offer the enterprising housewife unlimited opportunities for making attractive and artistic meals, which add appreciation to the knowledge of scientifically prepared food.

Some Good Combinations for Salads.

Raw spinach, sliced carrots, and onions, all cut very finely. Carrots, turnips and young green peas. If the peas are not young, cook all vegetables. Cooked artichokes and onions. Cooked Brussels sprouts and potatoes. Cooked asparagus and celery. Grated carrots, lettuce and beet. Celery, apple and lettuce. Cabbage, celery and apples with grated coco-nut. Tomatoes, grated carrots, cabbage. Tomatoes, cucumber and lettuce. Tomatoes, cucumber, sliced apple and carrots. Watercress, lettuce and spring onions. Beetroot, cabbage, carrots and lettuce. Carrot, apple, celery and raisins on lettuce. Grated carrot, apple and grated nuts. Radishes, cabbage, lettuce and leeks. Mustard and cress, radishes, lettuce and onions.

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* From *Journal of Agriculture* (South Australia), September, 1938, p. 221, Vol. XLII., No. 2.

Salad Dressings.

Never use vinegar for salad dressing. The food value of salads served with oil dressing is very high. The oil furnishes heat and energy and the vegetables supply valuable salts and a large percentage of water. Salads refresh without fatiguing, and strengthen without irritating.

French Fruit Dressing.—$\frac{1}{2}$ cup olive oil, $\frac{1}{4}$ cup orange juice, 2 teaspoons lemon juice, 1 teaspoon honey. Beat together until creamy. This may be varied by adding pineapple, grape, or grapefruit juice.

Plain Salad Dressing.—4 tablespoons olive oil, 2 tablespoons each of honey and lemon juice. Mix thoroughly with an egg beater. Use with any vegetable salad.

Mayonnaise Dressing.—To be used with vegetable salads. Yolk of 1 egg, 1 cup of olive oil, 2 teaspoons of lemon juice. Beat the yolk in a mixing bowl, adding the oil drop by drop. When this begins to thicken add a few drops of lemon juice and few more drops of oil until the desired thickness is obtained. For fruit salads add 1 tablespoon of honey.

Sunshine Dressing.—To 3 teaspoons of minced mint, add 3 teaspoons of honey. Cover and let stand in the sunshine for three hours. Add $\frac{1}{4}$ cup lemon juice. Strain. Serve on any salad that blends with mint. To this dressing may be added 6 teaspoons olive oil. Oranges or limes may be substituted for lemons.

POINTERS ON GOAT RAISING.

(By Carlos X. Burgos, Animal Husbandman.)

(Circular No. 185, Bureau of Agriculture, Manila.)

The raising of goats for meat purposes in this country is not difficult and does not require much time and effort by the owner. In fact, in every province goats can be found. They are usually unprovided with shelter other than what they may find for themselves, which may be a leaning tree, a log, an abandoned shack, a camarin empty, ermitas or what not. Very few ever take the trouble to build them comfortable sheds where they would be protected from rain and enemies.

They thrive on well-drained lands, and for this reason no places are better adapted to their breeding and keeping than rolling hilly sections and mountainous regions unsuited for raising crops.

According to our farm statistics for 1920, Pangasinan, Cebu, Illoilo, Capiz, and Leyte lead in the production of goats.

As the industry develops, the tendency is to raise goats for their milk also. To answer queries, therefore, as to methods and advantages of goat-raising, and in the hope of improving the present practices, this circular has been prepared.

Breeding and Selection.

It is best to start always with a small flock, preferably of pure breeds, or selected mestizos, but when these are not available, native scrub goats will do. Select the largest males for breeding. Fairly good breeding females should be placed in the breeding flock in the ratio of from 12 to 15 females to each male. The number of the females may be increased depending, of course, upon the constitutional vigour of the male. Goats should not be bred from until 16 to 18 months old. When allowed they breed even at 5 to 6 months old. Practice selection continuously and be sure to dispose of all undesirable stock and surplus males.

Feeding.

Goats will keep in good health and condition only where they have plenty of range and where they can find a variety of weeds and wild grains at all seasons. They especially relish ipil-ipil, aroma, and madre de cacao leaves and acacia pods. The idea prevailing is that goats live on almost nothing. This is incorrect and, moreover, they pay better if fed grain in addition to pasture grasses. It is particularly advisable to supplement the green feed of the animals with grain when they are pregnant or being milked. At the Alabang Stock Farm a mixture of equal parts of tiqui-tiqui (guintok in Visaya), corn meal and mongo meal is given every afternoon to *pregnant animals and those with young.* The amount is about a pint condensed milk-canful to each animal. It may be given moist or as a dry mash. Thin animals should be given this ration every once in a while also, and all need extra feeding if the pasture is not good. For the mongo meal may be substituted leguminous crops such as cowpeas, mani-manian, utao or soy beans, and others. The animals can be pastured on a field planted with the above-mentioned crops or rations of same can be given to them at night in the shed while sheltering. It is better to feed in feed racks so that they can not pull the feed out and drop it on the floor where it will be trampled on. Guinea grass and para grass are good for goats to pasture on.

The place where the animals roam for food should be abundantly provided with shrubs and bushes, as they are very fond of these. Goats eat all kinds of tree leaves. They even eat paper or any dry leaf of a tree. They eat weeds or anything else they can find in the field. It is a curious fact that goats, while pasturing, eat a little in one place and then a little in another place. They are always roaming about everywhere while grazing, but it has been noticed that, if put on guinea grass pasture, they eat the tender leaves of one hill before they go on to another hill. In a "saluyot" field they do the same. They eat all the leaves and leave practically nothing but the stalk.

There should be easily accessible for the animals a clean water supply. Otherwise they should be given fresh water regularly in clean containers at noon and in the afternoon. The water should be fresh and clean every time. *Salt should always be available,* as it is indispensible to digestion for goats as for all other animals. Rock salt is preferable.

Shelter.

Like other animals, goats need comfortable quarters to take refuge in at night and during hot or rainy days. A good shed can be made of bamboo and nipa. At least 2 square metres of space should be allowed for each goat. The shed should be low and the ground elevated. A platform should be built to serve as a resting place, especially when the ground floor gets wet. Well littered pens for pregnant goats and for those having young should be provided. This will separate them from the herd and from constant molestation by the males. The building should be located on a high place to ensure drainage. Where the main herd is kept, keep long benches or logs, sufficient for every one of the herd. They always prefer a hard dry elevated surface to lie on.

Three partitions should be provided—one for the pregnant, one for those having young, and another for the herd. The males should not be allowed to mix with the herd at night. Those for sale should be castrated or have a separate shed, as otherwise they may breed with the females in the herd.

The quarters and premises should be kept clean and dry all the time. A box for the excreta or manure should be provided. Later this should be scattered over the grass fields to fertilize the soil of the cultivated grasses.

Care and Management.

There should be shade trees in the pastures intended for goats.

The animals should be in the pasture at about eight in the morning and be driven back to the shed at noon. At two o'clock in the afternoon they should be driven again to the field to stay until sundown. Keep them away from dewy pastures, as dewy grass is liable to cause bloating. It is best, therefore, not to pasture very early in the morning while the grass is still wet with dew.

Animals that have just dropped kids should be confined and fed in pens for about a week or more until the young ones are strong enough to run with their mothers. Give them extra care. Give green and concentrated feed as suggested above. Give clean water every day. After the kids are dropped bury the afterbirth. When there is a sign of caked udder (hardened udder) a massage with hot water should be administered *right away.*

Young kids often have diarrhœa and sticky dung stuck to the anus. Wash the dung off with 5 per cent. creoline solution. Give the mother plenty of green grass.

The mother of ordinary goats may be milked after the kids are about three or four months old and regular milk goats much earlier. A goat that milks around a litre a day is considered a good milker. The lactation period is maintained from six to nine months. Any objectionable odour from the milk will be obviated if the billy goats are kept away from the milking nanny goats and rigid cleanliness maintained.

Have some sort of milking bench 35 centimetres high, one metre long and 60 centimetres wide. Build at one end a feed box and have on both sides two boards to keep the milking nanny on the bench.

Diseases.

FOOT-ROT.

Foot-rot generally attacks sheep and goats when their feet are always wet. They should *not* be allowed to run on wet ground. The dirt easily collects between the hoofs and stays wet and causes the disease. Bad smelling and wet quarters breed the foot-rot disease. Animals infected with the disease have swollen feet and are lame. The feet smell bad and generally exude a foul discharge. This is an infectious disease. It is best to separate the healthy ones and treat the affected animals with 450 grams of copper sulphate dissolved in 5 litres of warm water, allowing them to stand with their feet in the solution for five minutes. The infected place should be disinfected with 10 per cent. creoline solution or lime. As before said, *keep the place clean and don't allow the goats to get this disease.*

It is best to trim the hoofs of the animals twice a year. This will help keep the foot-rot disease away.

CONSTIPATION.

Constipation may occur among the kids. Give them a dose of castor-oil or epsom salts.

GID.

Gid sometimes prevails among goats. This is a parasite disease that attacks the brain and spinal cord of the animal. The cause is the presence of a larval tapeworm in the brain of the goat. The dog is also a host to this parasite. In the latter it develops in the intestine into a segmented form about 2 to 3 feet in length. These segments at the tail-end are full of eggs; they break off and pass out with the fæces and are thus propagated in the pasture. Animals that may chance to eat or swallow these eggs when drinking are sure to get the disease.

The animal attacked by this disease commonly turns in a circle. It may nibble grass for a while and all of a sudden raise its head and turn in a circle. This action is repeated by the giddy animal many times. When it is driven to its shed it walks with the head sideways.

To eradicate this disease, it is best to destroy the heads and brains of goats that die of it by burning; and by keeping dogs nearby free of tapeworms. The meat of a giddy animal is claimed by some to be good to eat provided it comes from a fat animal, but otherwise it should also be burned. However, it is *never* advisable to eat the meat of a diseased animal.

STOMACH WORMS.

The Bureau of Agriculture has had deaths among its goats along about the middle and towards the end of the rainy season. On opening the fourth stomach and the intestines of the dead, many twisted white stomach worms were found about 1 to 2 centimetres long. The symptoms previous to death were general weakness, loss of flesh and excessive diarrhœa.

Once the disease is detected, it is best to move the animals as often as possible to a fresh pasture and treat the entire herd with a solution of copper sulphate, which is extensively used in South Africa for sheep and cattle with stomach worms.

To prepare the solution, take 90 grams of clear blue crystals of copper sulphate and dissolve in 7 litres of warm water. (It is better to boil first part of the water and dissolve the crystals.) Give from 50 to 200 cubic centimetres of this solution per head depending on size and age. Dose animals while standing on all fours. Repeat this process after ten days. Bury deep or burn all the dead.

Miscellaneous.

Goats are claimed to be practically immune to tuberculosis, and for this reason goat milk is always preferable to cow milk for infants and invalids.

Proper care and strict sanitation will ensure success to any engaging in this industry.

MARKET FOR PAPAIN.

Papain is the dried latex tapped from the papaw fruit. This extract contains certain medicinal properties which are invaluable in the manufacture of various digestive preparations. The enzyme contained in it is required for making chewing gums, special foods and other pharmaceutical preparations. The value of papain, therefore, depends chiefly upon the enzyme content of the product. The only country producing crude papain on a commercial scale, if any, at present is Ceylon. The papaw tree (*Carica papayà*) grows not only in Ceylon, but in many other parts of the tropics, too. The increasing demand for papain has induced planters in East Africa and other tropical areas to investigate the possibilities of the production of papain. Recently, small supplies of this commodity from these areas were reported to have reached the London market.

The cultivation of the papaw tree is chiefly carried on in the Kegalla, Kandy, and Kurunegala Districts in Ceylon. A deep and well drained loamy soil and sufficient protection from strong winds are necessary concomitants if the best results are to be obtained. In Ceylon, the papaw tree also grows successfully as a catch-crop during the waiting period of return from tea or rubber. The production of crude papain in Ceylon was essentially a cottage industry which was carried on by peasants on a small scale, but the recent increase in the demand for this commodity encouraged the cultivation of the papaw tree on almost a commercial scale. Many small pure plantations therefore sprang up, and the increased production resulted in swollen exports to Europe and the United States of America.

The papaw tree comes into bearing in between eight and twelve months according to the degree of fertility of the soil and remains fruitful from four to five years. Production after the third year, however, is said to be less remunerative and it is therefore considered that the trees should not be retained thereafter.

The fruits should be tapped in the early hours of the morning. In Ceylon, tapping is always completed by 10 a.m. The fruits are not tapped daily, but at intervals of 4 to 5 days or more until they cease to yield latex. A knife of bone, glass or sharp-edged bamboo should be used instead of a steel knife in order to prevent discoloration of the latex. The actual tapping is no more than making shallow longitudinal incisions about an inch or two apart in the rinds of the fruits when they are still green, but fully grown. Further tappings may be carried on between the previous incisions made in the rind. A glass or porcelain receptacle held beneath the fruit collects the juice, which, on exposure to air, coagulates rapidly.

The yield of papain depends upon the soil in which the trees are grown, the variety, and the number of fruits per tree. The average yield of the dried juice per acre is about 100 lb. per annum in the first year of tapping on flat land

and 80 lb. per annum on hilly or rocky ground. In the second year, the yield diminishes by about half the quantity produced in the previous year. In Ceylon, as much as 175 lb. of the dried latex have been obtained per acre of good soil in the first year. Approximately 4½ lb. of fresh latex make 1 lb. of dry papain.

Immediately after collection, the fresh latex should be dried without delay in order to prevent putrefaction and decomposition. The addition of a trace of formalin solution to the latex as it is collected obviates this danger. So that valuable time may be saved in the process of drying, the coagulated latex may be squeezed lightly in a cloth or may be pressed through a colander or perforated plate for removing some of the water. There are two methods of drying the latex—sun-drying and oven-drying. If the former method is adopted, care must be exercised to see that the enzyme properties of the papain are not destroyed by over-baking it. The best results can be obtained by spreading the product on coarse linen stretched on frames and moving it frequently so that the drying is as even as possible. The temperature should be below 100 deg. F. This method of drying papain in the sun is suitable only where small quantities of the product have to be prepared such as in a peasant industry. But where huge quantities have to be treated on a commercial scale or where weather conditions do not permit of satisfactory drying in the sun, the oven forms a desirable drying apparatus. On large estates a hot air chamber can be employed, but the small producer would find it more suitable to use a drying stove. One form of such dryer consists of a chamber, 3 feet high, 3 feet wide and 6 feet long, the sides and ends of which are built in brick. About 1 foot from the top the chamber is divided horizontally into two compartments by a sheet of iron; beneath this, at one end, a small fire grate is constructed, whilst at the opposite end a chimney is built to lead the smoke from the lower compartment. In order to obtain an even heat in the upper compartment a layer of sand about 2 inches thick is spread on the iron sheet. The coagulated juice is spread on brown linen, stretched upon the frames which are made to fit the top of the dryer. As mentioned above, the temperature must be kept at a low level and at no time should exceed 100 deg. F. Coco-nut shells or charcoal are used as fuel in this dryer and the process of drying is completed in about six hours. This method of drying, it is urged, gives an almost white papain.

When completely dry, the papain should be roughly ground and then packed in air-tight tins enclosed in wooden cases, each containing about 100 lb.

The two grades of the product generally marketed are sun-dried and oven-dried papain. The oven-dried variety fetches a better price in the market on account of its very close approach to whiteness in colour and, in the United Kingdom, usually commands a premium of 3d. to 6d. per lb. over sun-dried. The underlying factor, nevertheless, which determines the value of the drug is the degree of enzyme activity in papain. It will be observed from the subjoined table that, in 1927, the average price obtained for papain was as much as Rs. 8.04 per lb., as against Rs. 1.96 per lb. in 1936, which was the lowest level reached in the last decade. There was a slight recovery last year to Rs. 2.14 per lb. The phenomenal increase in shipments to the United Kingdom and the United States of America in recent years, indicates a systematic extension of *papaya* cultivation in Ceylon, larger output and keener competition amongst exporters.

EXPORTS OF PAPAIN FROM CEYLON.

Countries.	lb.	lb.	lb.	lb.
United Kingdom	69,947	71,361	63,328	75,474
Australia	..	..	..	50
Canada	..	47	716	1,430
France	520	15,702	2,974	1,099
Germany	331	936	2,219	2,016
Holland	..	..	..	..
United States of America	32,780	67,228	158,726	116,447
Belgium	200	..	..	..
Cochin China	..	..	..	..
Total Quantity	103,778	155,274	227,963	196,516
Total Value	Rs. 590,849	Rs. 638,516	Rs. 447,165	Rs. 420,920
Average Value	Rs. c. per lb. 5.69	Rs. c. per lb. 4.11	Rs. c. per lb. 1.96	Rs. c. per lb. 2.14

(From the *Ceylon Trade Journal*, Vol. II, No. 12 December, 1937.)

CLIMATOLOGICAL DATA.

RABAUL (BOTANIC GARDENS)—LAT. 4° 12′ S., LONG. 152° 11′ E.; HEIGHT ABOVE M.S.L. 40 FEET.

Month, 1938.	Bar. Cor. to 32° F. M.S.L. and Standard Gravity from 9 a.m. and 3 p.m. readings.	Amounts of Clouds Means of—9 a.m., 3 p.m., 9 p.m.	Clear Days.	Highest Barometer Reading (Corrected).	Date.	Lowest Barometer Reading (Corrected).	Date.
January	29.757	7.2	8	29.878, 9 a.m.	12th	29.634, 3 p.m.	26th
February	29.758	8.5	6	29.917, 9 a.m.	26th	29.622, 3 p.m.	8th
March	29.756	6.2	11	29.874, 9 a.m.	3rd	29.663, 3 p.m.	24th
April	29.771	5.8	17	29.880, 9 a.m.	28th	29.668, 3 p.m.	4th
May	29.783	4.5	22	29.908, 9 a.m.	20th	29.685, 3 p.m.	2nd
June	29.866	5.5	18	29.914, 9 a.m.	10th	29.694, 3 p.m.	3rd
July	29.807	5.8	24	29.894, 9 a.m.	23rd	29.720, 3 p.m.	15th
August	29.799	4.5	25	29.894, 9 a.m.	8th	29.693, 3 p.m.	22nd
September	29.797	5.0	24	29.896, 9 a.m.	12th	29.672, 3 p.m.	19th
October	29.825	4.8	21	29.920, 9 a.m.	12th	29.681, 3 p.m.	28th
November	29.766	6.5	12	29.898, 9 p.m.	12th	29.657, 3 p.m.	6th
December	29.728	7.0	14	29.845, 9 a.m.	2nd	29.621, 3 p.m.	28th
Total	357.413	71.3	202	358.718	..	356.010	
Average	29.784	5.9	16.8	29.893	..	29.667	
Extremes	29.866 June 29.728 December	8.5 February	25 August 6 February	29.920	12.10.38	29.621	28.12.38

CLIMATOLOGICAL DATA—*continued.*

HUMIDITY AND RAINFALL.

Month, 1938.	Humidity.			Rainfall, Monthly, 1938.	Average Rainfall Since 1914.	Greatest Monthly Rainfall.	Year.	Least Monthly Rainfall.	Year.	Wet Days, Monthly, 1938.	Wet Days, Average Since 1914.	Greatest Fall in 24 hours.	
	Mean, 9 a.m.	Mean, 3 p.m.	Mean, Monthly.									1938.	Date.
January	79	79	79	12.10	14.32	37.74	1916	4.77	1918	23	21.0	3.01	16th
February	83	83	83	11.33	10.59	23.54	1923	3.38	1921	22	12.7	2.98	8th
March	76	65	70.5	5.96	9.53	22.23	1919	0.00	1915	20	18.8	0.90	29th
April	76	69	72.5	7.17	9.66	18.57	1925	0.93	1937	13	17.9	1.45	8th
May	76	66	71	4.02	5.07	11.27	1930	0.74	1932	9	13.2	1.47	27th
June	79	69	74	3.22	3.42	7.78	1923	0.79	1914	12	12.5	1.21	27th
July	79	65	72	1.25	5.55	18.00	1930	0.09	1914	7	14.6	0.28	10th
August	71	56	63.5	1.36	4.33	12.45	1937	0.36	1924	6	14.7	0.60	19th
September	68	56	62	2.20	3.67	7.15	1921	0.32	1914	6	12.5	0.91	5th
October	72	62	67	6.70	5.21	11.86	1928	0.62	1914	10	12.5	2.66	9th
November	75	65	70	5.34	6.41	14.23	1912	1.73	1933	18	15.5	1.08	30th
December	79	72	75.5	11.87	10.32	16.22	1919	3.66	1933	17	18.2	1.99	30th
Total	913	807	860.0	72.52	88.08	..	..	..	..	163	184.1	18.54	..
Average	76.1	67.2	71.7	6.04	7.34	..	..	..	..	13.6	15.3	1.54	..
Extremes	83 Feb.	56 Aug., Sept.	83 Feb., 62 Sept.	12.10 Jan., 1.25 July	14.32 Jan., 3.42 June	37.74 Jan.	1916	0.00 March	1915	23 Jan., 6 Aug., 6 Sept.	21.0 Jan.	3.01	16.1.38

Climatological Data—*continued.*

TEMPERATURE.

Month, 1938.	Mean.		Monthly Average, 1938.	Highest Maximum.	Date.	Lowest Minimum.	Date.	Lowest on Grass.	Date.
	Maximum.	Minimum.							
January	89.3	74.5	81.9	93.5	22nd	72.0	16th	70.0	16th
February	87.3	75.9	81.1	92.1	1st	73.0	27th	72.0	2nd
March	90.8	73.9	82.3	97.0	16th	72.0	30th	69.0	31st
April	90.1	74.1	82.1	92.5	15th, 17th	72.0	10th	70.0	10th
May	90.9	73.4	82.1	94.1	6th	71.0	4th	67.8	24th
June	89.7	73.3	81.5	93.0	6th	71.8	28th	69.0	28th
July	89.8	72.8	81.3	93.5	31st	70.3	3rd	67.7	23rd
August	92.3	73.0	82.6	95.3	29th	70.9	26th	68.0	26th
September	92.7	73.2	82.9	97.0	28th	70.9	12th	67.0	27th
October	91.6	73.5	82.5	96.5	1st	69.8	26th	64.6	26th
November	90.7	73.8	82.2	94.5	6th	70.2	29th	66.4	4th
December	90.0	74.2	82.1	93.2	23rd	72.2	14th	71.0	6th, 16th, 27th
Total	1085.2	884.7	984.6	..	..	..	..	..	..
Average	90.4	73.7	82.05	..	..	..	..	..	.
Extremes ..	92.7 Sept.	72.8 July	82.9 Sept. 81.1 Feb.	97.0	16.3.38 28.9.38	69.8	26.10.38	64.6	26.10.38

CLIMATOLOGICAL DATA—*continued.*

STANDARD TIME OF SUNRISE AND SUNSET AT RABAUL, 1939.

Date.	Sunrise.	Sunset.	Date.	Sunrise.	Sunset.
	h. m.	h. m.		h. m.	h. m.
January 6	5 46	6 7	July 7	5 58	5 52
13	5 49	6 10	14	5 59	5 53
20	5 53	6 12	21	6 0	5 55
27	5 54	6 12	28	6 0	5 55
February 3	5 56	6 13	August 4	5 58	5 55
10	5 58	6 13	11	5 58	5 55
17	5 58	6 12	18	5 56	5 55
24	5 58	6 10	25	5 53	5 53
March 3	5 58	6 8	September 1	5 51	5 51
10	5 57	6 6	8	5 47	5 50
17	5 57	6 3	15	5 44	5 49
24	5 54	6 1	22	5 40	5 47
31	5 53	5 57	29	5 38	5 46
April 7	5 52	5 54	October 6	5 35	5 44
14	5 51	5 52	13	5 32	5 43
21	5 49	5 49	20	5 29	5 42
28	5 49	5 48	27	5 28	5 43
May 5	5 49	5 46	November 3	5 27	5 44
12	5 49	5 46	10	5 27	5 44
19	5 50	5 46	17	5 28	5 46
26	5 50	5 45	24	5 28	5 47
June 2	5 52	5 46	December 1	5 30	5 51
9	5 53	5 46	8	5 31	5 53
16	5 54	5 47	15	5 35	5 57
23	5 56	5 49	22	5 39	6 0
30	5 58	5 51	29	5 42	6 4

PHASES OF THE MOON, 1939.

RABAUL.

January—	
6–Full moon	7.30 a.m.
12–Last quarter	10.10 p.m.
20–New moon	11.27 p.m.
29–First quarter	1.0 a.m.
6–Perigee	9.0 p.m.
21–Apogee	9.0 a.m.
February—	
4–Full moon	5.55 p.m.
11–Last quarter	2.12 p.m.
19–New moon	6.28 p.m.
27–First quarter	1.26 p.m.
4–Perigee	10.0 a.m.
17–Apogee	12.0 noon
March—	
6–Full moon	4.0 a.m.
13–Last quarter	7.37 a.m.
21–New moon	11.49 a.m.
28–First quarter	10.16 p.m.
4–Perigee	9.0 p.m.
17–Apogee	1.0 a.m.
April—	
4–Full moon	2.18 p.m.
12–Last quarter	2.11 a.m.
20–New moon	2.35 a.m.
27–First quarter	4.25 a.m.
1–Perigee	11.0 p.m.
13–Apogee	7.0 p.m.
28–Perigee	8.0 p.m.
May—	
4–Full moon	1.15 a.m.
11–Last quarter	8.40 p.m.
19–New moon	2.25 p.m.
26–First quarter	9.20 a.m.
11–Apogee	3.0 p.m.
23–Perigee	10.0 p.m.
June—	
2–Full moon	1.11 p.m.
10–Last quarter	2.7 p.m.
17–New moon	11.37 p.m.
24–First quarter	2.35 p.m.
8–Apogee	9.0 a.m.
20–Perigee	6.0 a.m.
July—	
2–Full moon	2.16 a.m.
10–Last quarter	5.49 a.m.
17–New moon	7.3 a.m.
23–First quarter	9.34 p.m.
31–Full moon	4.37 p.m.
5–Apogee	12.0 midnight
18–Perigee	9.0 a.m.
August—	
8–Last quarter	7.18 p.m.
15–New moon	1.53 p.m.
22–First quarter	7.21 a.m.
30–Full moon	8.9 a.m.
2–Apogee	10.0 a.m.
15–Perigee	6.0 p.m.
29–Apogee	1.0 p.m.

PHASES OF THE MOON, 1939—*continued.*

September—

7–Last quarter	6.24 a.m.
13–New moon	9.22 p.m.
20–First quarter	8.34 p.m.
29–Full moon	12.27 a.m.
13–Perigee	4.0 a.m.
25–Apogee	7.0 p.m.

October—

6–Last quarter	3.27 p.m.
13–New moon	6.30 a.m.
20–First quarter	1.24 p.m.
28–Full moon	4.42 p.m.
11–Perigee	11.0 a.m.
23–Apogee	9.0 a.m.

November—

4–Last quarter	11.12 p.m.
11–New moon	5.54 p.m.
19–First quarter	9.21 a.m.
27–Full moon	7.54 a.m.
8–Perigee	7.0 a.m.
20–Apogee	5.0 a.m.

December—

4–Last quarter	6.40 a.m.
11–New moon	7.45 a.m.
19–First quarter	7.4 a.m.
26–Full moon	7.28 p.m.
3–Perigee	5.0 p.m.
18–Apogee	2.0 a.m.
29–Perigee	9.0 p.m.

ECLIPSE, 1939.

A total Eclipse of the Moon, 3rd May, the beginning and ending visible generally in Australia, New Guinea and Western Pacific Ocean. Magnitude of Eclipse, 1.82 (Moon's diameter, 1.0). Begins, 3.28 a.m. Ends, 6.55 a.m. *Total Phase*: Begins, 4.40 a.m. Ends 5.43 a.m. (*Rabaul time*).

NOTES.

RAINFALL AND MOON PHASES IN THE TROPICS.(1)

On the low-lying east bank of the Demerara River, about 8 miles from its mouth, is situate Diamond Plantation, the largest sugar factory in British Guiana, located approximately at 6 degrees 42 minutes North and 58 degrees 10 minutes West. Preserved at Diamond is a valuable record of the daily rainfall for the past 46 years. Through the courtesy of the plantation authorities, I have been able to secure a copy of the register.

So many farmers and planters in the West Indies and British Guiana have faith in the new moon or the full moon bringing rain, that it seemed of value to determine, from the Diamond data, what actual foundation there is for the belief.

Popular belief does not definitely fix the fall of rain for the actual date of the new or full moon, but for some time near the date. Thus one frequently overhears such remarks as: 'It will be new moon to-morrow and we should get some rain to-night or to-morrow," or "the moon is full to-night so we may get some rain to-night or to-morrow." It was therefore decided to compare the average rainfall for (*a*) the three-day period made up of the day before new moon, the new moon day and the day after the new moon; (*b*) the three-day period immediately preceding (*a*); (*c*) the three-day period immediately following (*a*); (*d*) the three-day period made up of the day before full moon, the full moon day and the day following the full moon; (*e*) the three-day period immediately preceding (*d*); (*f*) the three-day period immediately following (*d*).

This was done for the year as a whole and for the dry seasons only, since it might be argued that it is only during the latter that farmers are worried about rain and trouble to note the supposed relationship between precipitation and moon phases. At Diamond the weekly rainfall averages less than 2 inches from the week ending 21st January to that ending 29th April, and again from the week ending 12th August to that ending 25th November. These periods were taken as constituting the dry seasons. During the rest of the year the rainfall averages more than 2 inches per week.

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(1) Reprinted from *Nature*, Vol. 139, No. 3510, February 6, 1937.

The results obtained for 259 new and 261 full moons (1914-1934), for the whole year, and for 147 new and 146 full moons, for the dry seasons, are set out in the accompanying table.

COMPARISON OF AVERAGE RAINFALL (1914-34) IN INCHES AT NEW AND FULL MOON WITH RAINFALL PRIOR AND AFTER AT DIAMOND, E.B., DEMERARA, BRITISH GUIANA.

—	New Moon.			Full Moon.		
	3 Days prior (b)	3 Days at (a)	3 Days after (c)	3 Days prior (e)	3 Days at (d)	3 Days after (f)
Year ..	0.81 + 0.06	0.82 + 0.07	0.78 + 0.07	0.85 + 0.08	0.74 + 0.06	0.93 + 0.09
Dry Season ..	0.50 + 0.06	0.51 + 0.07	0.51 + 0.08	0.48 + 0.07	0.50 + 0.07	0.62 + 0.10

The differences between the means are as follows:—

	Whole Year.	Dry Season.
a and b	0.01 ± 0.092	0.01 ± 0.092
a „ e	0.04 ± 0.099	0.00 ± 0.106
d „ e	0.11 ± 0.100	0.02 ± 0.099
d „ f	0.19 ± 0.108	0.12 ± 0.122
a „ d	0.08 ± 0.092	0.01 ± 0.099

It will be seen that none of the differences is significant and that there is no support whatever for the belief that there is likely to be more rain at the new or full moon than during the days just before or just after these phases. It is of interest to note, too, that the average rainfalls for the new moon and full moon periods are very similar.

C. Holman B. Williams.

TABLE OF SEA DISTANCES (in Miles).

From Rabaul to—		From Rabaul to—	
Aitape	613	Marienberg	515
Ambunti	702	Mortlocks	310
Buin	313	Muliama	120
Buka Passage	173	Pondo	96
Dutch Border	700	Salamaua	422
Finschhafen	368	Samarai	428
Gasmata	218	Sepik Mouth	477
Kalili	35	Sydney	1,845
Kavieng	163	Talasea	174
Kieta	258	Tasmans	460
Lae	417	Wewak	530
Madang	411	Witu	182
Manus	340		

ERRATUM.

Mr. R. J. A. W. Lever, Entomologist, Suva, Fiji, has kindly drawn our attention to an error in the bibliography of the article on "Coco-nut Improvement by Seed Selection and Plant Breeding," written by the Economic Botanist (See *New Guinea Agricultural Gazette*, Vol. 4, No. 3, July, 1938, reference No. 38, of the "Literature Cited"). The reference should have been as follows:—

Lever, R. J. A. W., (1935).—"The Green Coco-nut Bug (*Amblypelta cocophaga China*) and Induced Nut-Fall in the Coco-nut". B.S.I.P. *Agricultural Gazette*, Vol. 3, No 4, pp. 9-10, October, 1935.

It is pointed out that the work dealing with the particular figures mentioned was printed and published before the joint author, named in the other reference quoted, had arrived in the Protectorate. This mistake is acknowledged, so that workers interested may correct the bibliography of the article on "Coco-nut Improvement by Seed Selection and Plant Breeding".

NOTE RE "COCO-NUT THREAD BLIGHT."

With reference to the article on "The Diseases of Coco-nuts in New Guinea" also by the Economic Botanist (see *New Guinea Agricultural Gazette*, Vol. 3, No. 1, pp. 77-79), Mr. R. J. A. W. Lever has supplied the following interesting notes:—

> You may be interested to know that I took a specimen of coco-nut pinna, infected with "thread blight" to the Imperial Mycological Institute, when on leave (i.e., in 1937).
>
> The specimen was from Vella Island, British Solomon Islands, and, when I showed it to Messrs. S. Ashby (Director of the Institute) and E. Mason, it was found to be identical with *Corticium penicillatum* Petch, which, therefore, shows it occurs elsewhere, besides New Britain and New Ireland.

It is commented that this Department recognizes this disease as being very prevalent in Bougainville Island which, although part of the Mandated Territory of New Guinea, is really portion of the Solomon Islands Group.

PRACTICAL ASPECTS OF COPRA DETERIORATION.*

In this paper, Mr. Cooke has dealt with all the practical aspects of quality in copra. The entomological and mycological aspects of the same subject have been dealt with in Special Bulletin, Scientific Series, No. 20, of the Department of Agriculture, S.S. and F.M.S.

There is no real reason why bad copra should be produced anywhere in the world for, apart from very slight differences in oil content in the nuts of different countries, the quality of the meat is the same in all ripe coco-nuts from healthy palms all over the world. Differences in quality are due only to differences in care in the preparation of the copra and its subsequent handling, and it calls for no great amount of care, no high technical knowledge and no great expense, to prepare very good copra. For years the Departments of Agriculture of all copra-producing countries have been trying to educate local producers to prepare good copra, and to induce local traders to encourage its production. Yet even to-day the general standard of quality of the world's copra is appallingly low in comparison with the standards of every other primary agricultural product that enters into world trade.

Undoubtedly one factor that contributes to this is the fact, explained by Mr. Cooke (pp. 26 and 27), that, as copra deteriorates, while its oil becomes more acid, while moulds destroy its substance, it unfortunately happens that simultaneously the oil content of the remainder rises. Thus, though deterioration involves loss of weight and loss of quality in the oil and in the cake, yet no decrease—even a slight increase—occurs in the first figure the buyer looks at—the oil content of the sample.

This fact, however, does not entirely explain the present unsatisfactory condition of the world's copra, for, despite it, the miller of copra is prepared to pay more for good copra than for bad. The higher value of the good oil and cake that he can make from good copra outweighs the greater proportion of oil that he can get from bad copra. The reason why the amount of deterioration that occurs in copra is so great as compared with that in other comparable products, such, for instance, as palm oil, palm kernels, or cocoa, seems to lie in the system by which it is handled on the world's markets.

If one ships palm kernels, palm oil or cocoa from West Africa to Liverpool, New York, Hamburg or London, one sells on definite well-known clauses which specify the grades of quality with considerable accuracy and which are substantially the same in all these markets. In the case of the two former products, not only can one thus sell on a clause closely defining the quality of the produce, but the contract also provides for the payment of premia, or deductions of allowance, according to the variation of the parcel from the standard quality specified in the clause. In the case of cocoa, the system of futures, spot markets and defined grades provides more elaborate machinery serving the same purpose of combining the advantages of forward sale or purchase with a final adjustment of price with very great exactitude according to the exact quality.

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* From a review by O. T. F. in the *Malayan Agricultural Journal* XXV., No. 12, 1937, on " The Practical Aspects of Copra Deterioration," by F. C. Cooke, Special Bulletin, General Series No. 28, Department of Agriculture, S. S. & F. M. S., 1937, 49 pp., 3 plates.

For copra we have simply the two grades of f.m.s. and fair mechantable, and the forward sale of these grades as such. Compared to the grade definitions in other products the meaning of these copra terms is extremely vague. They really amount to little more than "fair average quality for the country concerned" and a quality distinctly lower than f.a.q. but still recognizable as copra. This vagueness of definition of grades and the inability to buy or sell a standard grade forward with subsequent accurate adjustment of the spot price according to the quality delivered, militate to discourage the buyer in the country of origin from paying more for superior quality. Until he does so, efforts to induce the producer to prepare a better quality naturally meet with little response.

This situation also renders almost impossible the introduction of any satisfactory system of official grading at source, such as has been introduced in recent years in respect of nearly every other important primary agricultural product that is marketed wholesale.

The special contracts made by some estates for regular sale of "estate quality copra" are not a contradiction of the statements made above; for though in such sales the buyer may get the exact quality he wants and the seller get the extra price his quality deserves, both have to sacrifice the great advantage of trading in the open market. In any event, this only affects estates, not the small holders who produce a large proportion of the world's copra.

The considerations set out above are not theoretical ones. Let any one who is interested in the matter ask, for instance, Messrs. Cadbury or Messrs. Rowntrees, if they would like to buy cocoa under the same conditions as copra is bought; and further, ask them if they think that the quality of cocoa from West Africa would be what it is to-day if there were not accurate definitions in the standard clauses of defining grades of cocoa.

Mr. Cooke discusses the range of quality of copra and the conditions under which it is marketed. He continues with a concise statement of the causes of deterioration and of the methods by which such deterioration may be obviated and concludes with a section on copra grading. The technique of preparation of copra must vary to suit local conditions, especially that of climate; but his recommendations are of a general character and simple to follow, so that there appears no good reason why the results of his investigations may not be translated into practice by producers at no great expense, and to the ultimate benefit of the industry.

REPORT ON SOIL SAMPLES FROM AIYURA AGRICULTURAL STATION, UPPER RAMU, NEW GUINEA.

(By J. S. Hosking, Division of Soils, Council for Scientific and Industrial Research, Waite Institute, Adelaide.)

The following notes accompanied the eighteen soil samples, representing three profiles, sent in by R. F. Brechin, Officer-in-Charge of the Agricultural Station, Aiyura:—

Nos. I. and II. profiles may be regarded as representative profiles of the soil in the bush country (of about 25 acres) now being cleared for Cinchona and Coffee Arabica. As many hundreds of tons of fallen timber, dead and decaying branches and leaves and leaf-mould remain on the surface, the surface samples are not a complete indication of the total organic matter present, or of the ash content.

No. III. profile is typical of the "alluvial flats" at Aiyura. Approximately 1,000 acres of this type of soil is present. This area is entirely grassland at the present time.

It is asked that the soil samples be subjected to the same analyses, as were the samples previously forwarded from Ramu, for comparative purposes. It will also be of interest to see how the bush country soil at Aiyura compares with the best Cinchona soils in Java."

The result of the soil analyses by Mr. Hosking is described as follows:—

The three profiles, first and second from the "bush" country and the third from the alluvial flats at Aiyura, are very similar to those already examined from the Upper Ramu Valley.

The soils are podsolised and consist of a thin layer of litter overlying a surface soil layer of dark brown to grey brown loam rich in organic matter to a depth of 12 inches over grey brown to light yellow brown (the yellow shade increasing with depth), mottled sandy clay or light clay subsoils.

The soils are acid in reaction. In the surface they range from pH 5.2 to pH 6.3 and rise to between pH 6 and pH 7 at a depth of 12 inches; in the lower layers the pH falls off slightly.

An adequate plant food supply is indicated by the figures in Table herewith.

TABLE 3.—ANALYTICAL DATA FOR SOIL SAMPLES FROM AIYURA, UPPER RAMU DISTRICT, TERRITORY OF NEW GUINEA.

Location.	Profile Number.	Waite Institute Sample Number.	Depth in Inches.	Moisture.	Loss on Ignition.	Soil Reaction.	Nitrogen.	K_2O.	P_2O_5.
				%	%	%	%	%	%
Bush Country	I.	5364	Surface	9.4	45.4	5.2	1.18	0.25	0.27
		5365	6	5.1	13.6	5.8	0.25	0.08	0.16
		5366	9	5.2	14.3	6.1	..	..	..
		5367	12	4.2	12.8	6.6	0.14	0.07	0.12
		5368	24	4.9	11.6	5.6	..	..	..
		5369	36	4.6	9.6	5.6	..	0.06	0.15
Bush Country	II.	5370	Surface	8.2	35.5	5.9	0.85	0.16	0.25
		5371	6	4.9	15.3	6.6	0.27	0.11	0.16
		5372	9	4.3	13.1	6.6	..	..	..
		5373	12	5.0	12.8	6.9	0.17	0.17	0.14
		5374	24	4.2	12.4	6.5	..	..	..
		5375	36	4.3	12.1	6.4	..	..	0.15
Alluvial Flats	III.	5376	Surface	4.7	22.8	6.3	0.38	0.17	0.26
		5377	6	4.9	12.5	6.2	0.17	0.09	0.14
		5378	9	4.9	12.2	6.2	..	..	..
		5379	12	4.4	10.8	6.7	0.15	0.15	0.13
		5380	24	4.6	9.8	6.4	..	..	..
		5381	36	4.7	11.5	6.2	..	..	0.14

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2715.

COPRA INFESTATION
BY
Ephestia cautella, Wlk.

(John L. Froggatt, Entomologist, and
F. O. Moody, Agricultural Inspector and Instructor.)

A recent occurrence of infestation by *Ephestia cautella*, Wlk. in this Territory, although known elsewhere, is of relatively unusual occurrence, in that the whole of the outside of the bags was smothered in webbing.

The Director, Imperial Institute of Entomology, London, advises that such occurrence as above has been recorded, but only when the infestation has been very heavy.

Life History and Habits.

The eggs of this moth are laid either on the bags or on the copra, the caterpillars, in the former case, entering through the bags onto the copra.

Corbett[1] has proved that the grubs of this moth mature quicker on mouldy copra, kept moist, than on good copra kept moist—on such copra kept dry, the life-cycle period was prolonged in each case, but was longer on the good copra—the minimum period of life-cycle was 22 days. Well dried copra is not considered good food for *Ephestia* caterpillars.

The infestation of copra by this moth, as well as by other insects, is closely associated with the moisture content of the finished product; inferior quality (mouldy and under-dried) copra is always more subject to attack than well dried and clean copra. As the copra dries out, so does the insect infestation decrease after a certain moisture content is reached.

Infestation in the Territory of New Guinea.

Considerable attention has recently been paid to infestation of copra by *E. cautella*, more especially in Australia, and the subject of the sources of infestation were gone into in detail in this Territory, by both writers, separately and conjointly.

As a result of these observations, it was evident that the initial infestation was occurring, in very many instances at least, in the storage sheds on plantations, although this was probably aggravated to a certain extent in depot sheds where the period of storage is prolonged.

Plantation Conditions.

On plantations, it has been, and, to a certain extent, still is, the practice to bag the copra the day after it is taken off the drier. This has been proved to be a bad practice, as the copra dries out for a further period of four to five days after removal, and if bagged and stacked immediately, will sweat in the bags. This only encourages insect infestation.

---

(1) Bulletin No. 20, Science Series, S.S. & F.M.S., Department of Agriculture.

XXVI, 31.

A better practice, and one that is now in more general use, is to heap the copra in a well ventilated but weather-proof shed for several days before bagging, the copra in the heap being turned over each day; this obviates sweating, and the copra of poor quality can be removed by picking over before bagging.

Factors Affecting Infestation.

It is an established fact in this Territory that well dried copra (i.e. with a moisture content of not more than 5%), will remain in good condition and free from insect infestation for long periods, whereas under-dried copra is liable to infestation soon after leaving the drier.

Contributory causes to infestation may be due to:—

1. Storage of copra in non-weather-proof sheds, resulting in bags becoming wet through rain.

2. Sweating of copra in sacks.

3. Loading from plantation to vessel, and from vessel to depot store in rain, or in leaking lighters, resulting in "wet bags".

In each case, the copra becomes damp and moulds supervene—a condition favorable to attack by various insects. Such copra, unless thoroughly re-dried, will be found infested in the stack, and leads to surrounding bags becoming infested.

4. There are parts of the Territory where owing to lack of anchorages, vessels loading copra at plantations have to lie off and send in lighters, often for appreciable distances. Owing to bad weather, especially during certain seasons, the vessels are unable to load and have to leave the copra behind, resulting in prolonged storage of up to three to four months on the plantation. Where predisposing factors exist, this condition lends itself to aggravation of the trouble.

5. Plantations are known in this Territory, where the mountain range is close to the boundary, and with spurs forming deep gullies that act as a funnel for a definitely cold land breeze at night even right onto the beach. Where stored copra is subjected to this cold wind, condensation of moisture will occur on iron walls and roofs which may drip onto copra the following morning, again assisting mould formation and insect attack. Wherever copra is subjected during storage to cold, humid changes in climatic conditions, a similar condition of copra will ensue.

6. Storage of copra and rice (especially) in the same or adjacent sheds.

7. Sacking of copra in old bags contaminated as a result of carrying in green coco-nut "meat" from the plantation or which have been used for sacking dried food products (i.e. rice or "sharps").

Consideration of the Shipment in Question.

In the case in question, the copra had been stored on the plantation in an old copra store made of native materials, and varied in age up to six weeks.

When unloaded at Rabaul, a very thin film of webbing was observed on the outside of the bags and, although the copra had been slightly under-dried when bagged on the plantation, it was not of markedly poor quality. There was, however, a quantity of frass and webbing on the copra, and numerous caterpillars were crawling over the outside of the bags. Examination of the copra showed that the "rind" of the copra had in some cases been eaten off, many pieces showing that the grubs had fed into the heart of the copra.

The advice of the writers was asked for, and immediate isolation and fumigation with hydrocyanic gas in the Government fumigator was recommended. The copra was shifted into a small isolated shed, and two unsuccessful attempts were made to fumigate in the stack in the shed. Ultimately, the consignment was treated in the departmental fumigation chamber with satisfactory results. Stacking in the fumigator was arranged in lines on dunnage and with dunnage between the two layers of bags, and space between the lines. This consignment of copra went approximately fifteen bags to the ton.

Measure for Minimization.

To carry out an efficient campaign, throughout the Territory, against this pest under existing conditions, measures would have to be undertaken in—

1. Plantation storage sheds.
2. Holds of inter-island ships.
3. Depot storage sheds.

1. It is evident from previous observations that fumigation of most, if not all, plantation copra storage sheds is impracticable from an economic point of view.

Whenever a copra shed is empty, however, it can be thoroughly cleaned out and sprayed with kerosene. This would kill a large proportion of the carry-over grubs, chrysalids and moths. Cases are on record, where this is done with excellent results.

Rice should never be stowed in the copra shed, as the former is subject to very heavy infestation by *E. cautella.*

2. If preventive measures were carried out generally on plantations, fumigating of ships' holds would probably only need to be done where rice already infested with the pest had been transported.

3. *Depot Storage Sheds.*—The practice of storing rice and copra in the same shed should be discontinued, as the former is only increasing the moth population for infestation of the copra.

Whenever a shed is sufficiently empty to enable a general cleaning out to be done, this work should be thorough; old copra and copra waste lying under "duck-boards", or other dunnage should be cleared away, and all beams, &c., broomed and sprayed.

Fumigation on a scale necessary to control the pest would be too costly with copra at its present low value. Provided that the sheds could be closed for 24-36 hours, and rendered sufficiently gas tight, calculations on the basis of quantity of copra through depot sheds in Rabaul, and the quantity of powder fumigant required, show that the cost of material would be about 1.10d. per ton of all copra handled during the year. The cost of sealing the shed would be additional.

A more feasible scheme, if such treatment is desired, is to build a special fumigating chamber to treat incoming copra that shows a sufficient degree of insect infestation to warrant the cost of fumigation, combined with thorough cleaning out of the storage sheds whenever practicable.

Investigations have been carried out by the School of Science and Technology of the London University on white oil-pyrethrum spray(2) for control of *Ephestia cautella* in dried food products stored in warehouses at the Port of London. On account of the spray, special apparatus is required for atomizing the fluid, but, after a consideration of existing conditions, some such method appears to offer possibilities for the treatment of sheds in this Territory, and should be worthy of close investigation.

In reference to the "Technique against caterpillars," Dr. Potter states (in reference to dried fruits) :—

> The method is mainly useful in stopping the spread of infestation and preventing re-infestation.
>
> The larvae of the two species of moths only come out of the fruit and expose themselves to the action of sprays when they are fully grown. Spraying is therefore of no use for goods infested with the early stages of the insect. In addition goods infested with fully grown caterpillars cannot be completely cleaned. This can only be done by means of fumigation.
>
> Spraying is used to prevent infestation in three ways. First, when infested goods are stored next to clean goods the fully-grown larvae may crawl out and infest the clean goods. By spraying the infested goods most of the wandering larvae are killed and so the spread of infestation is prevented. Secondly, when infested goods are stored in clean premises, they are sprayed to kill the full-grown wandering larvae and these insects do not reach the premises where they normally would over-winter. Spraying in this instance prevents the possibility of clean goods being infested by moths resulting from these caterpillars. Thirdly, when goods infested with caterpillars are taken away either to be fumigated and returned or to be replaced by clean goods, it is necessary to spray the site after the goods have been removed. In this way, larvae that have dropped off during the process of removal are killed. If this is not done the insects left behind are liable to infest any goods placed on that site.

---

(2) An account of the constitution and use of an atomized white oil-Pyrethrum fluid to control *P. interpunchella*, Hl., *E. eleutella*, Hl., in warehouses by C. Potter, B.Sc., *Annals of Applied Biology*, XXII , No. 4—1935. XXIV, 191.

OIL PALM PLANTING IN SUMATRA.

(Netherlands East Indies.)

By G. H. J. Van der Sluys.

The oil palms (*Elaeis guineensis*) which are now being cultivated with particularly promising results in the Netherlands East Indies, but especially in Sumatra, are all grown from seed. The history of the oil palm there dates back as far as 1848.

In 1848, the Botanical Gardens at Buitenzorg (Java) received four young palm trees of the variety *Elaeis guineensis*—two from Bourbon and two from the Hortus Botanicus at Amsterdam. Reports in 1858 stated that the four plants were growing vigorously at Buitenzorg, bearing abundant fruit, which was distributed freely.

The oil palms which are to be found on the various plantations in Sumatra to-day are all grown from the seed of these four trees and their descendants. It is a remarkable fact that these oil palms show very uniform type, whereas recent imports, from South Africa for instance, have shown a mixture of very different types.

The Government in Java started experiments in 1859, and planted a few acres with oil palms in the Residency Banjoemas (Java) and at Palembang (Sumatra). The official report given in 1864 stated that the experimental planting of *Elaeis guineensis* had been a complete success, and it can be said that the palm tree grows as well in Sumatra as in its native country, Africa, if not better, since it commences to bear fruit in its fourth year, whereas in Africa, it takes from six to seven years.

The history of the oil palm plantations in Sumatra begins in 1910. The Belgians, especially Mr. Hallet, must be credited with being the first to plant large areas with oil palms in the Far East.

Knowing all about the oil palms in West Africa, and seeing how exceedingly well the ornamental trees in Sumatra were growing, Mr. Hallet was convinced from the beginning that oil palms in Sumatra would be a success.

In 1911 the first areas were planted, and a few years after, before any practical results were obtained, over 6,000 acres had been planted, so great was the confidence of the promoters in the new industry.

The Great War brought further extensions to a standstill at the end of 1914, but in 1918 a total area of 8,500 acres had been planted. At the beginning of 1924 over 30 estates in Sumatra had been developed and planted with fine young oil palm trees, an area of 35,000 acres being in cultivation. In 1924 about 10,000 acres were producing. As the soil and climate of Sumatra, however, are very suitable for oil palm growing, these figures have increased considerably since that date.

Practically the whole of the present area planted, over 150,000 acres, is uniformly planted with the Deli-type, a good specimen of *Elaeis guineensis Jacq*, var. *dura*, whilst a fairly complete collection of other varieties is at hand for further selection work at the Experimental Station at Medan (East Coast of Sumatra).

The Sumatra estates are being scientifically developed upon results obtained at the east coast experimental station near Medan, world-famous under the title derived from the initials of its Dutch name, A.V.R.O.S., and with the advice of experts who are at the head of their profession. Evidence to date serves to prove that cultivated palms give a higher production than their indigenous relatives in West Africa and that it is possible for Sumatra palm oil to equal in quality the best African palm oil on the market. The aim of all connected with the industry, with its great prospects in the Netherlands East Indies, is to standardize the entire Sumatra output on a best-quality basis.

On the majority of Sumatra estates the oil palm trees are planted 30 feet x 30 feet apart, giving for the first four or five years an opportunity to plant a catchcrop. Profitable results have been obtained with Robusta Coffee planted out at a distance of 8 feet x 8 feet. This catchcrop shows no unfavorable results, and does no harm to the young trees, if carefully planted and not kept for a longer period than five years.

Developing.—The developing of an oil palm estate in Sumatra is carried out more cheaply than rubber, tea, sisal or tobacco. It takes less time and labour. After the forest is felled, burned and cleared (big trees can be left to rot away), a good straight lining of say 30 feet x 30 feet spacing should be started at once. This wide spacing has the effect of developing stout and short stems, thereby facilitating harvesting of the crop besides being more productive. Planting 30 feet x 30 feet on triangular system requires 56 trees per acre.

Fresh seeds are germinated in nurseries, which usually takes about four to five months after laying out, but may take eight months and longer. To hasten germination seeds are sometimes soaked in hot water for a few days, bringing the water to a temperature of about 115 degrees Far., thrice daily. Soaking the seed in sulphuric acid has been done, but does not give entire satisfaction.

When strong young plants have reached about 2 feet in height in the nurseries, they are planted out in suitably made holes of 2 feet x 2 feet x 2 feet in size. The young palm trees may be transplanted to the fields just as successfully when they are six months old, as when they are one and a half years, even two years old, so long as sufficient care is taken in transplanting. Large nurseries must be prepared during the first year of developing the estates.

The length of time the plants are to remain in the nurseries and the distance between the plants in the nurseries depends upon the season when planting out in the fields is to take place.

The upkeep of an oil palm estate is simple. When the plants have once become established, there is practically no trouble, as no root disease threatens the oil palms and very few pests are known so far. When no catchcrop is planted the usual cover crops, such as *Centrosema, Calopogonium, Pueraria javanica,* &c., are used. Some estates have four or five rows of *Tephrosia candida* in between the young palms, enriching the soil and keeping it covered. The oil palm thrives in a hot, humid climate and low-lying alluvial soil. It requires similar climatic conditions to cacao and a somewhat lower rainfall than the coco-nut palm.

Palm Oils.—The preparation of palm oil is carried out in a number of different ways, the methods employed depending upon the product sought. A low free fatty acid basis is demanded of oil that is to serve as a basis for edible fats. That oil with a low free fatty acid can be produced has been shown through many experiments in the laboratory, and in some up-to-date factories of the best oil-palm estates in Sumatra.

Before the war it was proved that palm oil with a low fatty acid basis could be adapted for the manufacture of edible fats and it was found that this fat was especially good for the preparation of margarine. The real pure margarine is no longer looked upon as the poor man's makeshift for butter in Europe; it is a good, wholesome, nutritious food.

The three main steps in the preparation of palm oil are heating, depulping and pressing. Whole bunches are transported, with as little bruising as possible, to the factory soon after harvesting. After the heating and drying of the bunches, the fruits are removed from the bunches by machinery. After this they are heated again, and pressed for the first time, depulped, heated and pressed from the pulp.

The structure of a ripe fruit may be roughly divided into pericarp, shell and kernel. The outer layer of an oil palm fruit represents the pericarp or pulp, composed of cells which at maturity contain the pericarp oil. The shell has no known commercial value, and its presence in a fruit means so much waste product. The centre represents the kernel, which yields the commercial kernel oil, and is the tissue that nourishes the germinating embryo.

The fruits on the oil palms in Sumatra contain an average of about 60 per cent. pericarp and 8 per cent. kernels, and the oil palm in Africa contains about 40 per cent. pericarp and 17 per cent. kernels.

The percentage of pericarp in the variety planted in Sumatra and F.M.S. is 50 per cent. higher than the average figure from Africa, but the percentage of kernels is only half that which has been obtained in Africa. Since the total value of palm oil from the pericarp is far higher than that of the kernels, Sumatra, or, in general, the cultivated oil palm, has a distinct advantage in this respect.

Very good results have been obtained in Malaya and the F.M.S. and, undoubtedly, there are districts in New Britain and on the mainland of New Guinea with climatic and soil conditions comparable to those of Sumatra oil palm plantations. Experiments in Papua prove that the oil palm will come into bearing just as quickly as on the east coast of Sumatra, Malaya and the F.M.S.

It is a crop, therefore, that is worthy of consideration by companies which are prepared to enter upon its cultivation on an extensive scale and invest a large capital to secure an up-to-date factory for the valuable produce of the oil palm.

Oil palm planting should yield a rich and adequate reward if a bold policy of rapid and extensive plantations is advanced, supported by the necessary capital to take advantage of the benefits to be derived from a large unit of mill-plant.

Cost.—The cost of planting and developing a large oil-palm estate of, say, 3,000 H.A., including all necessary buildings, factory and plant, can be estimated at £100 per hectare.

Oil palms from the 5th to the 10th year yield, when planted at the proper distance, 100 pounds (Dutch pounds) of fruit per tree, the fruit being separated from the bunches.

The separated fruit produces 60 per cent. pericarp and 8 per cent. kernel; the pericarp contains 40 per cent. oil, the kernel 50 per cent. oil. Taking 100 pounds of fruit per tree and the above percentage, it will appear that young oil palms, coming into their fifth and sixth year, produce per acre per annum—

Pericarp oil	0.535 tons.
Kernels	0.178 „

Mature oil palms should yield one ton of oil per acre, plus ⅓ ton of kernels, and the cost per ton f.o.b. should be £15 with freight, &c., at £6 per ton, or total cost will be £21 per ton.

Experience in Sumatra shows that profits range from £7 per acre for five year old palms to £20 an acre, when in full bearing. Estimating the returns at £37 per ton for palm oil and £19 per ton for palm kernels (average price on a number of years), the profit per acre should rise from approximately £6 per acre in the fifth year after planting, to £16 per acre in the tenth year. On a capital expenditure of £40 per acre, this profit shows a return of 15 per cent. in the fifth year, rising to 40 per cent. in the tenth year.

SUGGESTIONS FOR THE IMPROVEMENT OF NEW GUINEA COPRA—BAGGING AND SHIPMENT.

By E. Caulfield Kelly.

Whilst the quality of copra must necessarily be a first consideration at all times, the manner in which it is presented for sale in the open market can seriously influence the decisions of purchasers and appraisers, as regards price and grade.

Unfortunately, in New Guinea we have several factors which militate against the general appearance of a shipment of copra when it reaches the markets, and these, although in themselves they may be relatively unimportant as regards the actual quality of the product, serve to create a prejudice, at first sight, in the eyes of an inspecting purchaser or his valuer.

One of the principal of these factors is the bag or container in which the product reaches the market. Foul, filthy, patched and semi-rotten second-hand bags, with, frequently, one or more half-obliterated brands, designating previous contents, are all only too familiar sights when copra is being loaded for overseas at New Guinea ports, and suggest an appearance of neglect and lack of care for their produce on the part of the producers.

The spectacle of wharfs littered with what had been good produce, the contents of burst or rotten bags which have become torn in the ship's slings, and is being trampled upon by stevedores and crushed by trucks and, perhaps frequently, sodden by showers of rain, is unattractive and ugly, whether at the port of shipment or discharge, and could easily bias a consignee against a whole shipment on first appearance alone.

The musty and rancid odour of foul bags, emanating from the warm hold of a ship discharging, could also prove detractive to the general appraisement of a shipment, however good its quality on the plantation, and human nature is only too prone to take a possibly undue regard of such factors as slovenliness and outward appearance.

The loss annually to the exporting firms in this country must be enormous. Copra shipped in second-hand or half-rotten bags will, obviously, not handle easily; native labourers have little or no regard for the property which they load and unload from ships and depots; hook-torn and burst bags therefore result, and maltreatment and destruction of the produce is inevitable.

At Rabaul concentration depots, when local ships are unloading, it is quite common to see the holds of the ships covered to a depth of several inches with loose copra from broken bags, and, as the grades in such cases are so hopelessly mixed as to render separation quite unworthwhile, copra inspectors in the course of their duty are reluctantly compelled to request that all such sweepings, when re-bagged, be submitted in the lowest grade of the contained copra. This frequently results in a loss to the exporter of as much as £1 per ton over the price paid by him to the producer, for a considerable proportion of the sweepings affected.

Many overseas freighters also refuse to accept torn or damaged bags and, here again, the exporter is subject to considerable expense in the course of a year for re-bagging costs.

In the interests of the industry, therefore, sound, new and clean containers should at all times be used and, in their own interests, the exporting firms should cause all second-hand bags to be either destroyed or exported to rag dealers or paper manufacturers, rather than sold to plantations for the export of produce.

It is the practice, too, on many plantations in New Guinea to use new bags to carry freshly-cut coco-nut meat about the plantation for a period, and subsequently to dry out the bags, and ship copra in them. This practice is supported by the contention that bags are thus stretched, and will eventually hold more copra for shipment than new bags. A further contention—a rather parsimonious one—is that a certain amount of residual oil is left in bags so used, and this enhances the value of a shipment on the scales.

Against these considerations, however, such factors as the dirty appearance of the bags when finally shipped, the destruction of the fabric by oil and water, and the risk of fire by spontaneous combustion, are all lost sight of.

If new bags were used for shipment the additional expense to the planter could not exceed the cost of one more sack per ton of copra, and this would be considerably more than offset by the general appearance of his shipment, and its consequent enhanced value in the eyes of the consumer.

In exporting countries like Ceylon, Malaya and the Dutch East Indies, new bags are invariably used for shipment. Ceylon producers split their nuts at the drier, and dry in the half shell, so that the necessity for transporting green meat in bags does not exist. The bulk of copra exported from Malaya and the Dutch East Indies is made by native small-holders, and these employ baskets and such receptacles rather than foul new bags before shipment. The produce of these countries reaches the markets in a clean and attractive condition, and the whole appearance of their produce is reflected in the preferential price which it fetches.

It stands to reason, in the case of any commodity, that an article which is presented for sale in an attractive covering will be more in demand than a similar article presented in a clumsy or nondescript exterior, whatever the relative qualities of the contents. Fortunes are made in every walk of life by advertising experts, whose work lies chiefly in "window-dressing" and attractive presentations of the goods they advocate, and it is only reasonable to suppose that this applies in the case of copra.

Storage in the principal New Guinea concentration centres is carefully attended to by the exporting firms, and the greatest care is taken by the Department of Agriculture to ensure the best possible conditions of stowage in overseas vessels. Deadweight cargo, such as phosphates and concentrates, is heavily dunnaged with wood and canvas before copra is loaded on to it; the produce is always protected from contact with the sides of the ship by wooden batons and iron stanchions; hatch beams and coamings are draped with hessian to protect the bags.

It therefore remains for the producer to add his quota towards the general improvement in appearance of his produce on the markets by subscribing to the suggestions put forth above.

Even legislation might reasonably be introduced to provide for the shipment of produce in new bags, as a step towards raising the market status of the primary industry of the Territory; but, in the meantime, the local firms which purchase copra for shipment abroad should, in their own interests, insist on produce being offered for sale in sound and clean sacks.

RÉSUMÉ OF DEPARTMENTAL ACTIVITIES.

(Year ended 30th June, 1938.)

Agricultural Products.

Coco-nuts.—During the first quarter of the year, the ill-effects of the eruption were still noticeable, but there was rapid recovery in plantations and native groves after the nor'-west rains set in, with two or more exceptions.

Part of the damage was due to the accumulations of pumice weighing down the palm leaves, which, in some cases, was responsible for the collapse of the crowns, but where this did not happen, many of the fronds resumed their natural position, and the only loss was in the destruction of flowering spathes and immature nuts.

The greatest damage was caused by the cloud-bursts subsequent to the eruption, causing rushing temporary rivers which carried away some thousands of palms from Kurakakaul and Wunawutung Plantations. On the other hand, some plantations received a slight benefit, as chlorotic palms lost their sickly yellow colour and became a healthy green from some beneficial element in the pumice, though, on the whole, analysis indicated the presence of few elements of value to plant life. Pumice was the most important element present, while nitrogen and phosphates were low. The pumice also checked the growth of the noxious grass "Kunai" for a short time, which was of temporary benefit to the palms. An investigation of the damage done to the palms was made by the Economic Botanist, who reported that, with the exception of two or three plantations, the damage was mainly of income, and permanent loss was comparatively small.

On the south coast, Kokopo-road, large numbers of native coco-nut groves and whole villages were completely obliterated and covered to a great depth with pumice.

Coco-nut plantations in other parts of the Territory have had normal conditions, but production declined to a small extent when copra prices dropped, due to a slight decrease in the production of the native article. Plantation production naturally remains more stable as planters have their obligations to meet, whereas natives can be independent of their copra, which is mainly produced for the purchase of luxuries, and they will allow their nuts to waste, rather than go to the little trouble of curing copra when prices are low.

There is strong evidence that in some districts of New Guinea natives do select seed nuts for planting, having regard to the rough measurements of yield, size, weight and thickness of husk.

Fresh Coco-nuts (for the fruit market).—There has been little or no expansion in this side of the coco-nut industry, distance from market being the most important factor in militating against its development. There is but one man engaged in this business, and he acts as a middle-man, buying from a planter and giving slightly more than the ruling price for coco-nuts used in copra-making.

Desiccated Coco-nut.—Two only of the three desiccating mills have been working full time, producing 1,579 tons, valued at £73,423.

Coco-nut Peelings.—This is really the offal from the desiccating factory, and being of too inferior quality, even for passing as "trade" copra, approval is given for its export under the designation "coco-nut peelings" (402 tons exported of a value of £1,759).

Coir Fibre Mill.—The mill for the preparation of this product has been erected and has turned out a fine-quality fibre. It is superior to that imported from Ceylon, and has found a ready sale to Chinese upholsterers. Certain adjustments have yet to be made to the machinery before the company owning the plant is ready to prepare regular shipments to oversea markets. An interesting fact regarding the preparation of the coir fibre is that husks which had been lying in the field for about eighteen months produced as good a fibre with less trouble as fresh (dry brown) husks. The explanation, no doubt, is that exposure to the weather for such a long time served the purpose of retting and the fibre was not damaged.

Coffee.—Progress in this crop has not been as satisfactory as could be wished, but it is entirely due to bad management on the part of the owners. Coffee culture at low levels in New Guinea is being carried out on a fairly large scale, but so far its economic possibilities are not altogether clear, largely on account of the lack of management with sufficient knowledge of the crop, and because the labour has to be taught. Where this state of affairs has been remedied, the prospects are much brighter for this comparatively new crop, so far as New Guinea is concerned.

On one plantation soil conditions were unusually good, climatic conditions entirely favorable; but, owing to ignorance and neglect, everything was allowed to go back. A smaller plantation in the neighbourhood, but with poorer soil, is looking excellent, and is, at the time of writing, heavily in flower.

Arabian coffee, growing at Wau, 3,500 feet above sea level, is yielding record crops and bringing highest prices. This coffee was introduced by the Department from Jamaica nine years ago, and planted on the Department's little experimental station on the Wau, which has since passed into private hands. Some seed of this coffee has been planted at the new Agricultural Station, Aiyura, on the Upper Ramu, and is progressing well. Report states that the plants are thriving, and they should be in bearing four years from planting. The Lutheran missions are also growing Arabian coffee for their own requirements, and are encouraging the natives to plant it also, the crops being purchased by the mission. The samples of this native-grown product are very good indeed, and the enterprise of the mission in this matter is an instance of practical co-operation, which is greatly appreciated.

The export of coffee from the Territory amounted to 41 tons, valued at £1,025.

Cocoa.—Production of this crop is steadily increasing. The Department has supplied specially selected seed to planters from trees of second generation of high yielders, and advice has been given to planters by articles in the *New Guinea Agricultural Gazette,* correspondence, and inspection of plantations by various technical officers of the Department.

Owing to the lack of experienced cocoa planters after Australian occupation of the Territory, the export of this product had practically ceased. The trees had deteriorated from neglect, and on the Department's first attempt to resuscitate the industry, it was found necessary, in 1928-29, to advise that the trees on one of the oldest and best properties be cut hard back to form new trunks. The cocoa beans also were, in many cases, of such inferior quality that manufacturers at last would not look at them, some going so far as to say that New Guinea could not grow cocoa. By the action of the Department in growing specially-selected plants as mother-trees for the supply of good quality beans, and giving instructions in curing, there has been a decided change recently in the attitude of Australian manufacturers to New Guinea cocoa.

The general standard of our cocoa has been so raised that many shipments have been classed as equal to the best Trinidad on the London market, which has had a beneficial reaction on the Australian market.

Cinchona.—There has been excellent growth of all the Cinchona plants on the Upper Ramu, but the exceptionally dry weather experienced there has been some check to their growth. This will be overcome, no doubt, when the wet season sets in.

Tea.—Three hundred and fifty tea plants now growing at Aiyura, 6,000 feet, have been planted as mother-trees to supply seed to future tea-planters, for, naturally, it would be impossible to establish any new agricultural industry unless planting material was available. Many planters do not realize that tea seed, like that of many other tropical plants, is of extremely brief viability, so that many previous attempts to introduce tea seed to the Territory proved futile. The tea plant is also a very slow grower, and some years must elapse before it will be bearing seed. Owing to the restrictions on the export of tea-planting material from most countries, it has been extremely difficult to obtain such material for this Territory. The successful introduction, therefore, of even a few hundred tea plants into the Territory is of national importance.

Derris.—Every effort has been made to encourage the cultivation of this crop. In addition to using the indigenous *Derris elliptica*, the Director, on two occasions, brought different types of the plant from Malaya; in 1932 from Province Wellesley, and, in 1935, Changi No. 3 from Singapore. Derris requires cultivation like an annual crop, not unlike that given to sweet potatoes, but once the ground is covered, practically no further cultivation is necessary. One planter has made further inquiries about the crop, but local planters generally appear uninterested.

Rubber.—There are 1,800 ha. of rubber planted in the Territory, the greater part of which is *Ficus indica* (Assam rubber), which is not adaptable for plantation production. The proportion under Para rubber (*Hevea brasiliensis*) is small and little interest is taken in rubber production. A former rubber planter from Papua has, however, recently leased an abandoned area of Para rubber, portion of a large estate, and has every prospect of being successful. The rubber trees have been absolutely neglected for so many years that the tall secondary bush has grown up between the lines to form veritable jungle. This is all being removed to allow light and air to get to the rubber, which is responding with remarkable rapidity to improved conditions. The Department has helped this planter with suitable leguminous cover plants to keep down the undergrowth, and has given him advice for which he has expressed his appreciation.

There are numerous other smaller areas of Para rubber that could be profitably tapped, and advice has been given to the owners concerned; but, up to date, the only planter who has profited by such advice is the one to which reference has already been made. There are several Para rubber trees in the Botanic Gardens, all of which have been test tapped for latex production, and all the small yielders have been removed. The few remaining trees, therefore, should be good mother-trees for seed, as there are no poor yielders left to cross pollinate with them.

Vegetables.—Seeds of some European vegetables, including cauliflowers from Indian-grown plants, have been cultivated experimentally in different parts of the Territory. The results from cauliflower have been fairly satisfactory, as quite good heads have been produced in Rabaul and at the Demonstration Plantation. The cauliflowers will not go to seed at low levels in this latitude, but experiments are being made to produce seed at Aiyura and mission stations in the highlands on the mainland of New Guinea, and, if successful, the plants may even enter into the dietary of natives, as has been the case with shallots, tomatoes and cabbage.

Peanuts.—The cultivation of this crop is carried on to a limited extent, but, apparently, it is considered too much of a minor industry to warrant the attention of the local European planters. Its cultivation, however, has entered into the economic life of the native population, as it is always now found in their gardens, and has become a regular article in their diet. It is also to be seen for sale in native markets.

Jungle Products.—There has been practically no advance made in the collection and export of jungle products. Small shipments of rattan have been sent to Australia, but manufacturers there are able to obtain regular shipments from the East Indies, and it is only natural that small lots at irregular intervals would have little chance of sale on an open market. The efforts of the Department in this direction have, so far, been without satisfactory results.

Pests and Diseases.

A serious outbreak of *Promecotheca* occurred near Rabaul towards the end of the year. It was first observed by officers of the Department of Agriculture at the end of November, when the infestation was only slight, and an Inspector was sent out early in December to investigate. Advice was given as to how to deal with the pest by the only practicable methods known, and which were used successfully in the much greater infestation in the Philippines in 1931, where millions of trees were affected. Insect pests on plants like palms 30 to 60 or more feet in height are naturally more difficult to deal with than any ordinary orchard crop.

The local parasite *Eurytoma sp.* eventually brought this infestation under control. Colonies of this parasite have been distributed to other infested districts, and will be of assistance to an appreciable extent in keeping the pest down until *Pleurotropis parvulus* has been introduced.

The Coco-nut Tree Hopper, Sexava spp.—This serious pest still gives considerable cause for concern, but every possible means within the power of the Department is being used to bring it under control.

A power-duster for use primarily against this pest was imported, and reports so far indicate that it will be satisfactory.

Although *Sexava* parasites have proved effective in certain districts in controlling the pest, some factor, yet unknown, retards their effectiveness in the Manus group. There is good reason to think that poor soil conditions reduce the vitality of the palms, thus rendering them less resistant to both insect and disease attack. This is in accord with the views of leading authorities in entomology and tropical agriculture, who state that unsuitable soil conditions and improper plantation maintenance are the main causes of damage by insect pests and diseases. To improve soil conditions on the plantation where the Field Laboratory is established in Manus, experiments are being made with green manures and tall cover plants, also with the object of providing shelter for the newly-emerged egg-parasites (minute wasps) from strong winds to which the station is exposed.

A new *Diseases of Plants Ordinance* has been brought into legislation, giving power to the Department to compel growers to take action in controlling their pests and diseases, in accordance with the technical advice given to them by the Department of Agriculture.

Assistance to Planters.

As in former years, every possible assistance has been given to planters by the Department. Small quantities of economic seeds have been given, gratis, for experimental purposes. When necessary, an Inspector and Instructor, the Director himself, or other technical officers have gone to plantations for an inspection, and to render advice which, unfortunately, is not always taken, and, in certain cases, with serious consequences, of which the outbreak of *Promecotheca* is an example.

Planting material from selected cocoa and other trees has been supplied from the Demonstration Plantation to growers, in large quantities, for their plantations, and, in this way alone, a great deal has been done, not only to increase the quantity but also the quality of such products. In cases where it is found that the copra from a certain plantation continues to be of inferior quality, a letter is sent to the planter advising him of the fact, explaining the probable cause, and, if there is little or no improvement, an Inspector is sent to the plantation to correct the fault, with beneficial results. The same is also done with the cocoa planter, and it is hoped that, when the proposed cocoa inspection scheme is brought into force, no inferior cocoa will be exported from this Territory.

Samples of soil, &c., have been sent to the Council for Scientific and Industrial Research at the Waite Institute in Australia for analysis on behalf of planters, but, on the appointment of an Agricultural Chemist, this will not be necessary, as all such work can be performed by the Department.

Avenues in Rabaul.

The avenues that suffered severely from the eruption have recovered remarkably well—the result of the careful pruning they received. This is very noticeable, as trees that were in out-of-the-way places and overlooked and not pruned, never recovered, and, in some cases, even died.

Native Agriculture.

In establishing native coco-nut groves the custom was to instruct each male native to plant so many palms per annum, and no record was kept as to location of areas of groves, or even the number of natives employed. Consequently, the Department found the proper maintenance of such groves by an occasional visit of an Inspector and Instructor to a district an almost hopeless task. Efforts were then made to remedy this, and each Inspector was instructed to obtain full details of every coco-nut grove in the district patrolled and show its approximate position in the map. The work has been checked and re-checked in subsequent patrols, and a careful account is kept in the Head Office. In this way, the Department has fairly accurate particulars of almost every native coco-nut grove in the Territory, especially in Bougainville, where an agricultural officer is permanently stationed, and when each administrative district is so served, the native coco-nut industry can be put on a satisfactory basis.

In the neighbourhood of Rabaul, where the natives are more enlightened and sophisticated than those of the bush, they have been instructed in improved methods of copra making. The copra Inspectors at Rabaul, or other officers of the Department, make an inspection of the driers, whenever it is considered necessary, to remedy any faults in the drying methods, and, because of this, some native copra is even superior to the average plantation products. Other native copra is, however, still very inferior, and is usually passed for shipment as "trade". Native copra from Rabaul district amounted to 887 tons.

In addition to placing the native coco-nut growers on a more satisfactory basis, the Department is doing much to improve the general agricultural practices amongst natives by instruction from the agricultural officers on patrol, and, when Inspectors and Instructors are permanently stationed to each district, this work can be carried out even more effectively. Natives are naturally very conservative, and it would be quite useless to try and make scientific farmers of them in a generation. The Department's chief problem, therefore, is to find some alternative to their "shifting cultivation", which requires large areas and the burning of the trees, which is responsible for soil deterioration in native lands throughout the Territory. This evil is accentuated by natives being encouraged to grow money crops by this unskilful method, particularly in the neighbourhood of the larger European settlements. The Department is endeavouring to overcome this by modifying the methods employed in their gardens by the use of cover plants, rotation crops, and green manuring. It is obvious, however, that something more than advice and demonstration is necessary to overcome the evil which is doing incalculable harm to the Territory.

New food plants are introduced to native gardens, and strains of some of their own food plants are being improved in quality and quantity by selection, several of which have already been distributed.

Several of the missionary societies have rendered assistance in this work.

New Britain.—Native agriculture suffered such a severe check from the eruption that a long time must elapse before gardening conditions will be normal.

In some areas, near to the new volcano, natives have had to dig trenches 5 feet deep through the pumice to the soil beneath for planting their bananas. Other land could be made available for them, but they are so wedded to their own locality they they will not move. Efforts are being made to improve the raw pumice by incorporating green manures and other vegetable matter, so that sweet potatoes and similar food crops can be grown.

European vegetables are now coming into the native market in moderate quantities, and there is good reason to hope that this branch of native agriculture will soon be normal. In all other parts of New Britain the cultivation of native sustenance and money crops like coco-nuts is fully maintained.

New Ireland.—Native agriculture in this district is in a very healthy condition. In fact, in some cases, the natives have more coco-nut groves than they can maintain, and there is a sufficiency of food crops.

Kieta District.—The Inspector and Instructor stationed in this district has native agriculture organized on a very satisfactory basis, and all coco-nut groves are maintained in first-class order.

Manus.—This is one of the most unsatisfactory districts in the Territory for native agriculture—the soil being shallow—and natives depend largely upon sago (sak sak) and fish for their sustenance. An Inspector and Instructor has been stationed here, however, with the object of introducing shallow-rooting food crops.

Sepik.—An officer has been stationed in this district, and is putting native agriculture on a satisfactory footing. The soil in this district, on the mainland of New Guinea, is very suitable for agriculture, and native gardens there are large and well maintained.

ENTOMOLOGICAL.

P, Capt. B..

During the absence of the Director on leave from 12th November, 1937, to 19th February, 1938, the Entomologist was appointed Acting Director.

Contact has been maintained with entomological workers overseas and with a number of firms in England and the United States of America in reference to dusting and spraying machinery and various insecticides. Samples of several insecticides have been forwarded for testing as a result of this correspondence, and the latest information has been obtained on suppliers and prices for the use of planters.

Through the courtesy of the Manager, Levers Pacific Plantations Ltd., we have been kept advised of the work being carried out by the Entomologists in the British Solomon Islands on the problem of "nut-fall" caused by the *Coreid* bug, *Amblypelta cocophaga,* China.

Pest-control Machinery.—A 6 horse-power machine for dusting was received from England in February, 1938.

Two different types of power-spraying machines are on order, both from England.

A mechanical, hand-operated, dust mixing machine is on order from the United States of America.

Insecticides.—Calcium arsenate and lead arsenate have been obtained in quantity from Australia for field trials against insect pests, especially *Sexava.*

From inquiries made overseas, it has been found that the prices of insecticides are much less than those operating in Australia. Supplies have been ordered accordingly, and comparative trials will be made to test the relative toxicity and other properties.

Pest Infestations.

Coco-nuts.—*Sexava* infestation that had been severe on portions of both the east and west coasts of New Ireland in 1936 had cleared up by the early part of the latter half of 1937. There had been a similar infestation in the Rabaul-Kokopo area of New Britain about the same period, but this had also cleared up by the time stated above.

In the Manus District some plantations reported a moderate to severe *Sexava* infestation about the same time. Outbreaks of this pest were also reported on some plantations in the Madang District during the later months of 1937.

In all the above districts, a little *Sexava* feeding is always in evidence.

Along the north coast from Rabaul, an outbreak of *Promecotheca antiqua* started at the end of November, 1937, and a severe infestation rapidly developed. Signs of parasite control were observable by the end of March, 1938, in one portion of the area affected, and in the other sections by early in May; the former is showing good recovery, but the latter sections will take much longer to develop full foliage.

Aspidiotus destructor was reported from the Western Islands to be causing damage to coco-nut palms, and a colony of predaceous *Coccinellidae* was forwarded from Manus to assist in controlling the pest.

Palm weevils, Rhynchophorus spp., caused a considerable amount of damage in certain areas in the Kokopo District, and necessitated the use of regular pest gangs and considerable supervision to maintain control.

Cocoa.—The weevil, *Pantorhytes plutus,* has continued to cause trouble in cocoa in parts of New Britain; one planter has reported a good measure of control by spraying the trees with arsenate of lead. Inquiries from other cocoa-producing countries have failed to elicit any records of this weevil, and no information was available on any possible parasites.

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Rhyparida obscuripennis and other spp. of *Rhyparida* (*Eumolpidae*) have caused damage to young tip foliage when occurring in any numbers, resulting in tip malformation and stunting.

A *Lepidopterous* stem borer, *Zeuzera coffeae,* Nietn. (*Cossidae*) has been occasionally met with.

Larvae of *Cerambycidae* have occurred fairly frequently in branches of cocoa, and *Dictamia* sp. has been bred out from one lot of infested material.

Two species of *Thysanoptera* (*Heliothrips haemorrhoidalis,* Boisd., and *Selenothrips rubrocinctus,* Giard.) have been collected on cocoa foliage in both the Kokopo area and in the Kieta District; it has not so far been found to be a serious pest.

"Mealybug", *Pseudococcus* sp., has been collected on the base of the stem of cocoa plants growing in a slightly sandy soil, but has not been serious.

Coffee.—"Mealybugs", *Ferrisia virgata* and *Pseudococcus* spp., have caused considerable damage to coffee trees, and *Leucaena glauca* as shade, in both the Kieta and Bainings Districts. Variation in shade materially lessened the attack on the Bainings property.

The "hard scale", *Coccus viridis,* is general in occurrence, and its control has necessitated a considerable amount of spraying with oil sprays.

The same *Lepidopterous* stem borer, *Zeuzera coffeae,* Nietn., as occurs in cocoa is occasionally met with doing similar damage to coffee trees.

General.—Various pests have been reported on vegetables.

Ants in dwellings and on schooners have been subjects of inquiries during the year, and suggestions and demonstrations for control have been given.

The first flush of growth on trees and shrubs in Rabaul after the eruption continued to be very severely attacked by various *Lepidopterous* larvae, and this called for a considerable amount of attention. Larvae were collected and adults bred out for identification from a large number of host plants.

Achaea janata (Noctuidae), a serious pest of castor oil plants, was bred from hosts not previously recorded in the Territory.

Sexava Research.—This has been continued, and special attention paid to the use of insecticides against this pest, both arsenicals and derris and pyrethrum mixtures being tested; in laboratory cage trials, calcium and lead arsenates gave the best economic results, and field trials have therefore been confined to these two insecticides. Owing to the late arrival of the power-dusting machine, the field trials are not as far advanced as was hoped would have been the case, but it appears evident from the results to date that a very high percentage of the "hoppers" are killed by an application of either of these insecticides into the heads of the palms, and the costs appear to be strictly moderate, especially with calcium arsenate. Further work is planned to test other fillers than lime to ascertain comparative adhesive powers, as the foliage of coco-nuts is so exceedingly smooth as to offer but little mechanical adhesion of dusts.

The breeding of parasites for liberation is being maintained, and tests with "tanglefoot" banding have been continued.

Distribution of Sexava Egg Parasites.—Colonies of parasitized *Sexava* eggs have been distributed, both from Manus and from New Hanover, to various sites in the New Ireland District, and, also, to New Britain, where *Sexava* is known to be present. Distribution from New Hanover offers the possibility of transference of at least three species of parasitic *Microhymenoptera,* two of which have been found to be extremely difficult to breed in the laboratory in numbers sufficient for liberation under field conditions.

Promecotheca Research.—Studies of the life-history, habits and parasites of *Promecotheca antiqua* have been carried out in both the Manus and Rabaul Districts. The life-history of the larval parasite, *Eurytoma* sp., occurring on New Britain, was studied in Rabaul, and was bred in the laboratory in sufficient numbers to permit of distribution in localities in the infested area already referred to where the parasites were slow to make their appearance in appreciable numbers.

Egg and larval parasites of *P. antiqua* have been bred out in Manus by Mr. O'Connor, Assistant Entomologist, from material collected in the field. A detailed study of these parasites will be carried out as opportunity offers.

Pleurotropis parvulus.—This larval and pupal parasite of *Promecotheca ritchei* was imported from Java into the New Hebrides at the end of 1937, and arrangements were then made to obtain a colony for this Territory as soon as the parasite was established in its new habitat. The colony was duly forwarded by M. Dupertuis, but, owing to various unforeseen and unavoidable delays in transit, the period during which they had to be kept in cold storage was so prolonged that the whole colony was killed. Plans for a further introduction of this useful insect are in hand.

Moth Infestation of Copra and Rice.—Considerable attention has been paid recently to this problem, which has been a serious matter for a considerable time past, but a Territory-wide campaign is required for its successful control. After a study of the pest, *Ephestia cautella,* in storage sheds on plantations and at main storage depots, and on inter-island vessels, it is evident that the initial trouble lies on the plantations, but the trouble may be considerably aggravated during long storage in main depot sheds. This moth also has been the cause of complaints regarding cocoa beans from this Territory.

Plant Quarantine Inspection.

Inspection of plants entering the Territory, particularly through the port of Rabaul, has been maintained, and any material carrying live insects was fumigated.

Insect Collections.

The insect collections have been maintained during the year, and a large number of specimens have been added from various parts of the Territory.

Over 600 specimens have been despatched to the Imperial Institute of Entomology, London, and 358 identified species have been received from that Institute. In addition, other specimens have been forwarded to specialists—*Coccidae,* Dr. Laing, British Museum of Natural History; *Cicindellidae,* Dr. W. Horn, Berlin; *Collembola,* Mr. Womersley, South Australian Museum; *Mallophaga,* Mr. G. B. Thompson, British Museum of Natural History—from all of whom identified species have been received.

Of the material sent to the Imperial Institute of Entomology, 40 species were retained for further study, 92 species were listed as "further specimens desired", and 12 species were not in the collections of that Institute.

Timber Pests.

In conjunction with the Forestry Officers, breeding of pests of timber has been carried out, and specimens of all insects bred out have been supplied to them for their collections.

Information on timber pests already known in this Territory has also been supplied to these officers.

ECONOMIC BOTANY.

Plant Breeding Investigations.

Owing to the broken time occasioned by travelling, this work was not advanced as far as could be desired; nevertheless, progress was made during the period under review.

Coco-nut cross-breeding and seed selection have now been well established at Keravat. This work was carefully discussed in the article on the subject published in *New Guinea Agricultural Gazette,* Vol. 4, No. 3, July, 1938, page 24, which also outlines future work. Since that time, however, successful artificial cross-pollination was carried out on a large scale between a dwarf variety, King Coco-nut, and the Markham strain of coco-nuts, which is also a definite regional type. Thirty-three King Coco-nut palms were crossed with five Markham type of palms as pollen parents. A total of 1,095 flowers were pollinated, and an approximately 30 per cent. take was recorded on the first count; a small late fall is expected.

The final objective was the combination of a large nut, the size of the Markham type, with the early maturity of the dwarf coco-nut, so as to reduce the period at which coco-nuts come into profitable bearing.

Only the best palms in both types were selected, as all inferior palms were marked and cut down, so as to avoid their presence in the planted areas.

The difficulties of controlled cross-breeding of coco-nuts to produce early maturing palms are not so great as is generally believed, providing the various varieties to be used are in isolated blocks, as is the case at Keravat.

It was proved, in the course of this work, that some of the palms showed an hereditary tendency to produce nuts with poor germination. In fact, some palms, although appearing normal as regards size of nut and amount of kernel, were found to be hereditary non-germinators.

As palms producing nuts of low germination or a high percentage of weak sickly plants are most undesirable, the importance of the seed selection, plus nursery and seed selection carried on at Keravat, is indicated as a sure guide to plantation practice.

The Department of Agriculture has also carried on a great deal of coco-nut introduction, and representative collections from outside countries, as well as from various parts of New Guinea, are being grown in connexion with the breeding programme mentioned. Most interesting and valuable introductions have recently been obtained through the courtesy of the Director of Agriculture, Fiji. The six selections received are the result of coco-nut cross-breeding by Marechal, between the Fijian dwarf palms, named Niu luka, and the Malayan dwarf palms.

It is claimed that these resultant selections may commence to bear coco-nuts before the spathes rise above the ground. Improved selected strains of coco-nuts from Menado Coco-nut Experimental Station, Celebes, N.E.I., were also introduced. A supply of "Macupuna" nuts was introduced from the Bureau of Plant Industry, Manila, as being especially valuable for native food requirements.

Original investigations on the floral biology of coco-nuts were also commenced both at Keravat and on outside plantations, such as Meto, Witu Group.

Coffee Cross-Breeding.—The following crosses were successfully made between Java strains and Keravat selections of coffee:—

K.B4 x Bangelan 105–01–K4.
K.B6 x Soembar Asim Selection No. 78.

Also between Bangelan 105–01 (K4) and Bangelan 105–01 (K21), both selections from the Bangelan strain, which is doing well at Keravat.

It has been found that two coffee selections made from bulk plantings have compared more than favorably with Java strains, sown under the same conditions and at the same time.

In the coffee selection block, seedless strains of the shade tree *Leucaena glauca,* comparable with the "lanang" strains of this tree from Java, were found, and later isolated. As the production of too many seed pods is the disadvantage of this tree, these seedless types are valuable.

Cacao Improvement.—Cacao is more liable to self-pollination than crops such as coffee and coco-nuts, which are more liable to cross-pollination. Generative or seed selection thus has a sounder basis and greater hope of success with cacao than is the case with the other crops mentioned. The diversity of types present shows that some out-crossing does occur, thus vegetative methods are necessary before any complete uniformity is obtained.

Several of the best cacao trees at Keravat were selected for yield and uniformity of quality, and were increased into clones or vegetative populations, as far as possible, by budding and approach grafting, both "fan" and "chupon" scions being employed for comparison. In most cases, the selected "mother" trees were grafted back on their own seedling stocks, so as to increase the material available for distribution and further testing on a larger scale.

Rubber Test Tapping.—Test tapping of rubber, *Hevea Brasiliensis,* was again carried out in the Botanic Gardens, Rabaul, and, after the results were available, all inferior trees were cut out altogether to allow of cross-pollination between superior yielding types only. Seeds of the trees which are left are intended for planting in test areas.

The eruption interrupted the continuance of the second series of tests, but these were later recommenced when the trees had recovered sufficiently, with the object of isolating heavy yielding strains.

It was found that the trees which yielded best in the first test also did so in the second test, despite the altered environmental conditions. In this manner, ten high yielding "mother" trees were isolated, of which Rabaul No. 608 was easily the best in the both tests, and yielded more than three times as much as the mean yield for all the trees included.

Large rubber nurseries were established, but owing to the eruption spoiling the young trees, very little progress was made with bud-grafting as intended. It is an important finding that high yeilding strains of *Hevea* are present in this Territory.

Tests instituted by a private planter on an old established rubber area in New Guinea, show that our natives can be taught to tap rubber satisfactorily.

PLANT DISEASE INVESTIGATIONS.

Manurial Deficiencies in Coco-nut Palms.—This work was commenced, although there was at the time no chemist present, as it was considered urgent that some aspects of the deficiency problem in coco-nuts and coffee soils be dealt with, despite the fact that this was not strictly within the province of the Economic Botanist.

Chlorosis, deficiency diseases and general debility in the coco-nut palms in some plantations, which are due to soil exhaustion and are also inter-related with the age of the palms, are the greatest problems to be faced in New Guinea plantations.

Preliminary tests have served to indicate that there is a very big and important field of research available on these problems.

Coco-nuts suffering from *chlorosis* in the Bainings District, and more particularly on the north coast of the Gazelle Peninsula recovered their green colour remarkably well after the recent volcanic deposition had taken effect.

Analyses have shown that the pumice and ash were rich in soluble potash and gypsum ($CaSO_4$), but very low in phosphoric acid and nitrogen. It must be remembered, however, that there were rare metals and substances, such as magnesium, contained in this ash, which undoubtedly had some effect as did the temporary choking of kunai, *Imperata arundinacea*, and other weed growths. There is some rather definite proof that either unbalanced nitrogen and potash content or actual potash deficiency are involved as important aspects of coco-nut *chlorosis* in the Gazelle Peninsula.

Owing to the lack of data and because of conflicting results with single fertilizers, a test was conducted with a complete fertilizer consisting of a mixture of sulphate of ammonia, sulphate of potash and superphosphate, the rate of application being 8 lb. per individual palm, unmanured plots being included for comparison.

Although it was too early for the effect to be seen on the palms, the effect of the manure on the ground flora was most noticeable.

It was indicated that on the manured trees, the kunai tended to be choked out by a dense growth of softer grasses, sedges and legumes, showing that kunai becomes only dominant on nitrogen deficient soils in the presence of excess sunlight.

This effect only appeared where the manure was applied, and it further emphasized that cultivation, cover cropping and manuring are closely inter-related problems, and that they could well follow in rotation, and in the order mentioned.

Direct methods of injecting ten different chemicals into the coco-nuts through auger holes made in the trunks of coco-nut palms, were tried, using strengths of solutions ranging from 1/200th to 1/1600th. Cobalt chloride, borax, zinc sulphate, copper sulphate, magnesium sulphate, ferrous sulphate, solid iron citrate, sulphate of potash and sulphate of ammonia, were the chemicals used, and some of these gave immediate and beneficial effects. Iron sulphate has also been tried out on plantations as a manure, and has given good results.

From what can be seen from preliminary tests, there is practically a general deficiency of manurial ingredients in the soil here, while the nitrogen status and water holding capacity is not good. Much more field experimentation combined with pot culture experiments, and soil and leaf analyses, which are the province of a chemist, are required.

Thus experiments with erect cover crops such as *Crotalaria*, *Tephrosia* and *Leucaena glauca* are being initiated as is the investigation of rare metal deficiences.

By applying better cultural methods, eliminating kunai and establishing leguminous cover plants, several plantations have been greatly improved recently, though they were formerly believed to be almost irrecoverable.

Tests with applications of solid compounds of all the substances mentioned, to be applied direct to the palms, are under way.

Coffee Diseases.—In the larger New Guinea coffee plantations, it was noticed that the presence of *chlorosis* or yellowing in the coffee bushes was extremely prevalent in certain areas. It was also noticed that several kinds of plants, growing in close proximity to the coffee areas, showed a related *chlorosis*, showing that the deficiency was general. Citrus trees growing near the coffee showed a distinct mottled *chlorosis*, combined with shortening and deformation of the leaves. It was also observed in patches of *Desmodium scorpiurus*, bananas, native grasses, *Crotalaria* and on a native bush tree *Leea* spp.

Chemical analysis of the soil on this particular plantation, seemed to indicate that a general deficiency was involved, although the percentage of potash (K_2O), soluble in 1 per cent. citric acid, was high.

It appeared, however, that there was a marked lack of balance between the amount of nitrogen and potassium present, and that the ratio was too wide. Cover cropping and the use of waste coffee pulp and compost was recommended. After every effort was made to keep up the humus status of the soils by planting *Crotalaria* and cover crops, the coffee areas improved greatly.

Root Rots.—Diseases of this nature caused mainly by the fungus *Fomes lamoensis*, which causes brown root-rot, were prevalent in coffee plantations last season. Several other fungi, however, were involved in other specimens received from Bougainville and Wau. Specimens have been sent to Professor Ashby, Director of the Imperial Mycological Institute for identification of the fungi concerned.

In one case, over 2,000 Arabian coffee plants growing at low levels became badly diseased, and had to be cut out. Root-rotting fungi were present, but it is believed that they were secondary in their effect to that of soil conditions, density of shade and other environmental factors, as another area in the same plantation, remained quite healthy. This was also confirmed by the fact that a species of *Diplodia*, which is usually associated with "Dieback" was found on twigs of this coffee. *Polyporus zonalis* or other species, was the fungus mainly associated with cacao root-rotting at Keravat.

Coco-nut Diseases.—Professor Ashby considered that the physiological disease present in coco-nuts just coming into bearing may be identical with the "Cadang Cadang" disease described by Ocfemia in the Philippines, and believed to be a virus disease. In August, 1937, this physiological set-back was again seen at Namatanai in palms reaching the bearing stage, but, as the palms soon recovered, it is believed that the condition is almost certainly physiological, due to the extra demand for water and nutrients at this critical stage, not being met under certain dry weather conditions on a heavy soil.

It was recorded that a "gummy leaf" condition of coco-nuts, where the fronds failed to expand properly, was common on the Witu Islands, where strangely enough, the "Head Droop" common on New Ireland and other places, was not seen. As these palms seldom bear nuts, it is recommended to destroy them.

Areas where falls of mature coco-nut palms occurred were investigated at Witu and Bougainville, and a gazette article for publication was prepared on this subject. In one area restriction of the root-system, due to a hardened layer present in the sub-soil zone, caused the palms to fall over in strong winds, after they had reached a certain height.

Plant Introduction and Plant Exchange.—This work has been carried on with other countries on a fairly large scale. The state of the nurseries due to the eruption, as well as the loss of young plants occasioned by it, curtailed the work in the Botanic Gardens to some extent last season, but the introduction of desirable new economic crops for Keravat proceeded as before.

In addition to other crops, new varieties of tobacco, citrus, avocadoes, mangoes, kapoolasan nuts, cloves and vegetables were brought in, together with numerous ornamental plants.

Coco-nut Literature.—As the Department of Agriculture is particularly interested in coco-nuts, steps were taken to compile a complete bibliography and index on all aspects of coco-nut culture, but especially as regards diseases, seed selection and plant breeding.

Investigations by the Department of Agriculture on forest products, have been largely discontinued as this work now comes within the scope of the newly formed Forestry Section of the Lands Department. It is as well to indicate, however, that one species of a thin binding rattan, collected from the Sepik River, has distinct commercial value if it is present in sufficient quantity. Investigation has also been conducted on the candlenut, *Aleurites Moluccana,* but, although the candlenut oil, at a favorable price, should find a definite use in the paint and varnish industry, its commercial exploitation is not promising, where the Australian crushing firms require the nuts to be opened and the kernels extracted here.

Poisonous Plants Seen in New Guinea.—The following list of plants should be of interest as being known to have poisonous properties:—

Barringtonia speciosa	
Derris elliptica *Derris uliginosa*	One of these responsible for the death of natives last year.
Exoecaria agallocha *Exoecaria acuminata*	Known to natives and recognized by them as a deadly poison.
Asclepia curassavica	Cottony milk weed or red top. Many times recorded as having killed cattle here under certain circumstances.
Jabotrya Curcas ..	Seeds are especially dangerous.

HERBARIUM.

Most of the doubtful identifications in the Botanic Gardens were checked by collecting dried specimens and sending them to Kew and to the Government Botanist, Queensland, for identifications. Such named trees and plants were then adequately labelled.

An extensive Herbarium collection made by Kajewski in Bougainville Island and presented to the Department a few years ago, was properly mounted and carded. The identifications of this collection were recently supplied as far as possible, through the courtesy of Dr. E. D. Merrill, Director of the Arnold Arboretum, United States of America.

Specimens of timber trees present here, and collected by the Forestry Officers were retained in the Herbarium and identifications are gradually being received. It is hoped to grow any newly identified trees in the Botanic Gardens as a living arboretum as far as can be arranged.

BOTANIC GARDENS.

The main work of the year has been associated with the rehabilitation of the gardens after the severe damage caused by the eruption, and the subsequent floodings. The gardens have made a remarkable recovery, although they do not appear so attractive as formerly, owing to broken-off branches of trees not being replaced, and because the lawns have not fully recovered. The not inconsiderable percentage of salt ($NaC1$) present in the dust plus the tendency of the soft palpable dust to set has done considerable damage to small soft and newly-introduced plants, but this effect is gradually disappearing.

Ferneries and rockeries have all been replaced and repotting carried out several times.

Manuring with compost is being carried out continuously and thoroughly with material prepared from town rubbish and night-soil, treated by the Indore process, which work has been greatly facilitated by the assignment of a motor lorry to the gardens.

The work of re-conditioning the Botanic Gardens has been handicapped by the lack of an adequate water supply during a spell of dry weather amounting to almost drought conditions. Attempts were made to plant grasses in the lawns, but this has met with only moderate success on account of the factors indicated. The nurseries were severely set back by continued floodings, carrying pumice, and because of the unsuitability of the new volcanic deposits for plant growth. This is being overcome gradually. The large, new, and rather unsightly drain running through the gardens to carry off excess flood water was bridged, at intervals, with artistic cement bridges, by the Chinese carpenter. Hedges of casuarinas and bamboos were grown to hide the bare and raised banks, which are being gradually levelled and covered.

The main paths skirting this drain, and those running through the gardens, have been widened and levelled; they now require metalling or gravelling.

All of the plants present in the gardens were listed according to botanic classification, and in alphabetical order, and set out on suitable plans and sheets. The plants were all labelled with aluminium labels on which the lettering and numbering was carried out with a new embossing machine, which has proved very handy. These labels are for necessary permanent marking and nursery work, but do not display the lettering like enamel or porcelain labels.

Numerous gardens and hedges in the town of Rabaul, which had been destroyed, were replanted or else planting material supplied for them.

A new Chinese cemetery has been laid out to meet future needs.

ECONOMIC SECTION.

The nurseries, although full of young plants of coffee, citrus and rubber at the time of the eruption, were covered with so much eruption deposit that they have been unsuited for this purpose since. Decided attempts have been made to alleviate the soil in the main areas by growing erect, green manure crops, such as *Leucaena glauca, Tephrosia candida, Crotalaria* spp. and cow peas, which are cut down and dug in at intervals. It is believed that this area will not be available for cropping until it is composted all over and artificially manured, which work will necessarily take some time.

DEMONSTRATION PLANTATION—KERAVAT.

During the year under review, the cultivated area of the plantation was increased by 120 acres and 94 acres were felled in preparation for clearing next year. The total area at present under cultivation, and in the course of clearing for cultivation, amounts to approximately 500 acres.

As development progressed, the newly cleared areas, and areas of fallen bush, were linked by roads to the older established sections of the estate. Approximately 274 chains of new roads were constructed, and, at the close of the year, the roads available for vehicular traffic totalled 6¼ miles.

A large creek, which is 70 feet from bank to bank and 20 feet deep, was bridged to provide road communication between the new area and the existing cultivation.

Further long-term experiments were laid down in respect to coffee, cacao and coco-nuts. A yield trial of taro and a cultivation trial of mammee-yams were completed, and individual plant selection experiments commenced with these two important native food crops.

Meteorology.—The rainfall during the year was 87.13 inches, which is 21.59 inches lower than last year. The heaviest falls occurred in August, 10.26 inches; September, 10.87 inches; and January, 9.73 inches.

Plantation Activities.—

PERMANENT CROPS.

Cacao.—Maintenance work in connexion with this crop was carried out during the year, and yield records kept of all selected trees.

The young area of bulk selected cacao which was planted in September, 1935, commenced bearing. It is pleasing to note that an examination of the trees as they come into bearing shows that they are producing beans of the desired colour, shape and size. Therefore, this section should provide excellent material for furthering selection work. Although in this area, shade density has some effect on the height of ramification, it would appear, at least with hybrid cacao, that this factor of ramification is in all probability somewhat generic, as in the four rows that were devoid of shade from the beginning, the height varied from 1 foot to 6 feet.

Ten Keravat selections and one Djati-Roennggo Hybrid ex. Java were planted in another section. The experimental lay-out of this block provides for a yield trial and observation of the eleven selections. At the close of the year, very good growth of the seedlings had taken place; a number have commenced to ramify and it is again evident that factors other than shade have some bearing on the height of ramification.

A spacing experiment was set out at distances of 12, 13, 14 and 15 feet on the equilateral triangle system. The 12, 13, 14 feet sections were planted and the seedlings are growing well.

A further block was planted with cacao and the area was divided into four equal sections, each containing 2.5 acres, and each section was planted with a single permanent shade tree variety, and two varieties of temporary shade. Five rows of each of the eleven cacao selections were planted in each section, in such a manner that when the block is taken as a whole, the selections are randomized throughout. During the coming wet season two varieties of creeping leguminous cover crops will be established. The experiment is designed to observe and compare the temporary and permanent shades, ground covers, and cacao selections; also for yield trials of the cacao selections and, later, pruning and manurial experiments can be conducted.

Another block was cleared and prepared as follows for cacao experimentation. It was divided into three sections—

No. 1 section lined 14 feet by 14 feet,
No. 2 section of 15 feet by 15 feet,
No. 3 section of 16 feet by 16 feet,

on the "quincunx" pattern. Each section was further divided into four equal parts, namely, A, B, C, D. The A and C portions were planted with Kong-kong taro; the B and D portions with Kaffir Corn, as native food catch crops. When the catch crops have been harvested, *Tephrosia candida* or *Leucaena glauca* is to be planted as temporary shade, and, in the next wet season, each of the sections A, B, C, D will be divided, and half planted with selected seedling cacao, and half at "stake" with selected seed.

A laboratory experiment was conducted to observe the germination and growth of the cacao bean in respect to the position of the hilum in the soil, and the depth of planting. The experiment was fully described and published in the *New Guinea Agricultural Gazette,* Vol. 3, No. 2, December, 1937.

Cacao Budding.—In December, 1935, seedlings were taken from selected mother trees, and planted out in a separate block; the rows were 15 feet apart and thirteen seedlings were placed 15 feet apart in each row. In February, 1936, six seedlings from a selected stock number were also planted in the same rows.

When the seedlings had made sufficient growth, they were to be budded with "fan" and "chupon" buds from the mother trees, and, during the current year, this work was commenced. Unfortunately, it had to be discontinued as unfavorable weather conditions occurred, but it is hoped that the work can be carried out in the coming year.

Cacao Selection.—Cacao selection was carried a step further during the year, and a number of first filial generation selections was made.

In the month of September, a number of mother tree selections were made at Asalingi Plantation, in the Bainings District, and the manager kindly consented to record the yields. It is interesting to note that in a letter received from the manager towards the close of the year, he stated that all the selections were producing well, a number would exceed the yield standard originally laid down, and that one tree had produced over 40 lb. of dry cacao in nine months.

Approach Grafting.—Fifteen "approach" grafts of seedlings to mother trees were made in each of the cacao selections and towards the end of the year, nine grafted seedlings from each tree were planted out. It is hoped that by this method of "approach" grafting the main characteristics of the mother tree will be reproduced, and that a quick method of establishing the original mother trees will be evolved in order to provide an additional number for the supply of planting material.

Coffee Selection.—The coffee selections introduced from Java and Malaya in 1935 commenced bearing during the year and a number of selections was made. When these introduced selections were planted a number of Keravat selected numbers were also planted in parallel rows with them for comparison purposes. Observations to date, indicate that in growth and early bearing, the Keravat selections compare very favorably with the best of the introductions.

Coffee Manuring.—Towards the middle of the year, an area of young coffee was manured in order to further observe the effect of single fertilizers on *chlorosis.* Sulphate of ammonia, nitrate of soda, superphosphate, sulphate of potash, and blood and bone were used, and applied at the rate of four ounces per tree. The observations made confirmed those in last year's trial on mature coffee, namely, that shade density appears to be the limiting factor. Where the shade was inadequate the number of chlorotic trees increased despite the applications of fertilizer, and where the shade was good a reduction in *chlorosis* occurred.

Selection Trial.—The trees in the selection trial which were planted in November, 1936, commenced flowering during the year. It is interesting to note that the Jackson's Hybrid selections are growing better than a large number of *Robusta* selections.

Spacing and Selection Trial.—An area was prepared towards the close of the year for a spacing and selection trial. It was divided into four sections, namely, A, B, C, D. Section A was lined and holed at 10 feet on the "Square" system, section B lined at 10 feet on the "equilateral" triangle system, section C at 8 feet on the "square"; and section D at 8 feet on the "equilateral" triangle. In the next wet season, these sections are to be planted with selections made from the introduced Java and Malayan strains, and the Keravat first filial generation selections.

Coco-nuts.—The area under coco-nuts was increased during the year by the addition of seedlings from Numa-Numa Estate, Bougainville Island.

Manurial Observations.—Manurial observations during the preceding year showed that the young coco-nuts improved when single fertilizers were applied, and, in the present year, a mixed fertilizer made up of 2 parts of superphosphate, 1 part sulphate of ammonia, 1 part sulphate of potash, was applied at the ratio of eight ounces per palm.

The beneficial effect of the mixture was very noticeable towards the close of the year, and a further aplication is to be made at the beginning of the coming wet season.

Spacing Experiment.—One coco-nut area was divided into three sections and lined, holed and planted at distances of 25 feet, 27 feet 6 inches, and 30 feet on the "equilateral triangle" system.

Cross Breeding.—A series of cross-breeding experiments were commenced during the month of March. King Coco-nuts (dwarf) were crossed with selected large nutted, heavy bearing, Markham Valley Coco-nuts (tall). A total of 1,095 flowers on thirty-three King palms were pollinated by five Markham Valley palms.

The first count of "set" female flowers took place in June and approximately thirty per cent. had taken.

It is worth recording that one Markham Valley palm that was used was planted in September, 1934, and at the age of 3½ years when the pollen was taken, it had ripened five coco-nuts and was carrying a crop of seventy.

Oil Palm.—The Oil Palm section was maintained and pruned during the year, and oil samples were prepared for the Australian Exposition of 1938.

Rubber.—In January, 1937, seed from a number of selected *Hevea brasiliensis* seedlings was received from the highest yielding trees in the Rabaul Botanic Gardens, and planted on the estate.

Fruit and Nuts.—The Philippine Islands Breadfruit are growing exceptionally well, and produced their first small crop.

Rambutan and Avocado Pear again bore crops, and a "free stone" Rambutan variety introduced from Java in 1934 produced its first crop; the fruit is large and juicy.

A variety of Achras sapota (Sapodilla) introduced from Java in 1934 produced its first small crop, and the fruit is large and excellent in flavour.

The Hawaiian and Queensland varieties of Paw-paw continued to yield good crops. Pineapples bore prolifically throughout the year and two recently introduced Malayan varieties, namely, " Singapore Canning " and " Sarawak ", ripened their first fruits, which were of good size and flavour, and had a small core.

The Banana areas produced fruit continuously during the whole year; the bunches were large and well formed, but a large percentage of the fruit was damaged by the fruit-moth in the opening " hands ". Six varieties, including Gros Michel and Dwarf Cavendish, were selected from the bulk banana areas and planted in multiplication rows.

The Queensland Nut section (oldest portion planted in May, 1933) did not flower during the year. A small number of Brazil Nut seedlings were planted in the field but failed.

Root Crops (*Native Foods, &c.*).—The principal crops in cultivation were taro, yam, mammee, cassava and sweet potatoes.

Taro.—In April, 1935, multiplication of twenty-six varieties of native taro and observation trials were commenced. During the year under review, yield experiments were conducted with the best nine varities selected from the original twenty-six. The experiments showed acre yield variations from 7,815 lb. to 15,725 lb., and maturing period ranging from 173 days to 191 days. The five highest yielding and shortest maturing varieties were named and a further series of comparative yield trials commenced; suckers of these varieties were also planted in six row blocks, and early in the coming year individual plant selection will commence. Planting material from the two highest yielding varieties was distributed amongst the natives in a number of districts during the year.

A further twenty-one new varieties were collected and planted in multiplication rows.

A comparative yield trial of two new varieties commonly cultivated by the local natives, and two of the named Keravat selections were conducted. The results showed that although the period of maturity was similar, the yields of the new varieties were significantly lower than the Keravat selections.

A large leafed *Xanthosoma* spp. of taro, locally known as Kong-kong taro, was tested as a possible native food temporary shade crop in establishing cacao. It proved highly successful as a native food, but failed to provide the necessary protection for cacao during the dry period of the year.

Yams.—Experimental work in connexion with yams was commenced, and ten varieties were planted in multiplication rows.

A method of single plant selection and multiplication of the " Taitu " variety was evolved towards the end of the year, and experimentation will commence as soon as the current crop matures.

Mammees.—An experiment was conducted to ascertain whether and difference in yield occurred from staked or unstaked mammees. It was found that staking produced a slightly higher yield, but it was so insignificant that the time and expense in erecting the stakes were not warranted.

Two named native taro varieties, " Standard " and " Mammoth ", were used in a native food comparison trial with mammees. The " Standard " variety yielded at the rate of 15,700 lb. per acre with a maturing period of 175 days; the " Mammoth " variety yielded at the rate of 15,625 lb. per acre with a maturing period of 188 days, and the mammees yielded at the rate of 17,380 lb. per acre with a maturing period of 269 days. This series of comparative experiments are not yet complete, but the data available indicate that the cultivation of high yielding, quick maturing taro varieties as a quantitative food is probably preferable to mammees.

Two strains of mammees were selected during the year and planted in multiplication rows, one strain grows downwards and the other grows upwards.

Sweet Potatoes.—The cultivation of this crop was again retarded during the year on account of attack by the larvae of the moth, *Hippotion celerio,* and the Sweet Potato Weevil (*Cyclas formicarius*).

A small crop was harvested and was the first complete harvest of sweet potatoes for two years. Although the area was attacked from time to time by the larvae of *Hippotion celerio,* the damage was not so severe as in previous crops, and the presence of moderately large numbers of the Giant Toad (*Bufo marinus*) probably gave a fair measure of control.

Arrangements are in hand to conduct a series of experiments in the coming year to ascertain the controlling effect, if any, of *Bufo marinus.*

Cassava.—This crop was kept in cultivation, and, although a good native food, its difficulty of eradication once harvested prevents any large areas being planted.

Minor Root Crops.—Small demonstration areas of minor root crops, such as *Canna edulis* and *Maranta arundinacea* were kept in cultivation.

Annual Grain Crops.—The main annual grain crops in cultivation are Maize, Rice and Kaffir Corn.

Maize.—Selection of the Keravat strain of maize was continued and large quantities of seed distributed for cultivation in different parts of the Territory. Reports received from outside districts are very favorable regarding the cultivation of this strain for native food purposes. The plants are robust and quick growing, free from disease, and produce large well-formed ears with plenty of grain.

The " Fitzroy " variety which was introduced last year continued to give good results and in the near future should be worthy of distribution on a large scale to be used as native food.

Two new varieties were introduced from Hawaii, namely, White Guam and U.S.D.A. 34. Neither variety have proved very promising as yet, but they are improving as they become acclimatized. The variety of U.S.D.A. 34 is a sweet corn type and may be of value in the future for table purposes.

Rice.—Rice was kept in cultivation throughout the year; field selection to maintain uniformity was carried out, and a moderately large amount of seed was distributed. One parcel of seed was supplied to an Aboriginal Settlement in North Queensland, Australia.

Kaffir Corn.—Kaffir Corn was in constant cultivation during the year and proved invaluable as a quick crop to control weed and grass growth immediately after clearing.

An attempt was made to introduce Kaffir Corn as a native food but was unsuccessful; the labourers on the estate admitted that the flavour was equal to that of green maize, but complained that it was indigestible and unattractive in colour.

MARKET GARDEN SECTION.

During the year, a market garden section was commenced, the object being to test various varieties of vegetables and fruit, with a view towards ascertaining the best types and varieties for cultivation at low elevations.

Lima Bean.—In the month of July, three varieties of *Phaseolus lunatus,* and three varieties of *Phaseolus multiflorus* were introduced from Australia. Five of the six varieties failed, but a strain of *P. lunatus,* known as U.S. No. 2, produced a small amount of seed which after harvest was planted in multiplication rows. This variety is now growing and producing very well, the beans have exceptionally good table qualities and a number of seed distributions was made during the year.

Cauliflower.—A number of tropical cauliflower varieties was introduced at the commencement of the year. The plants grew very well, but the maturing period coincided with the wet season and the crop failed. Further seed was obtained, and, as it arrived at the close of the wet season, the plants at the present time are showing every indication of maturing before the wet season and producing well-formed heads.

Rock Melon.—Two varieties of rock melon, namely, " Rocky Ford " and " Hales Best ", were planted at the beginning of the dry season and a good crop matured. Healthy plants producing good fruit were selected from this crop and plants raised from the selected seed are now growing well, are healthy, and it is apparent that another good crop will mature before the wet season. As it will be possible to grow two crops during the dry season of the year, Rock Melons during this season have definite potentialities as an adjunct to the usual tropical fruits for table use.

Lettuce.—Three varieties of lettuce, namely, " Tom Thumb ", " All the Year Round ", and " Green Mignonette ", were successfully grown throughout the year.

Cabbage.—Success was obtained from the " Early Drumhead " variety of cabbage, but " Early St. John's Day " and " Aphis Proof " were failures. Other varieties are at present under trial.

Fibres.—Demonstration areas of the principal fibres, Manila hemp, Amani Sisal Hemp, Sanseviera Hemp, Sisal Hemp, Pineapple Fibre, Banana Hemp, Kapok, Jute, Cotton, Red and White Rozelle Fibre, were maintained during the year.

Spices.—A small demonstration area of pepper, vanilla, turmeric, ginger and cinnamon was maintained during the year.

Annual Oils.—Groundnuts were in continual cultivation, the varieties Red Spanish, Pearl and Rhodesian being mostly used. Groundnut issues were made from time to time to the native labour, and local orders for seed and food purposes were maintained.

A small area of two varieties of *Sesamum indicum* was kept in cultivation.

Drugs and Medicinal Plants.—Small demonstration areas of tobacco, *Tephrosia vogelii, Hydnocarpus anthelmintica,* and castor oil were maintained.

Insecticides.—A number of *Derris elliptica* selections was in constant cultivation, and a strain of *Derris Philippinensis* was introduced.

Cover Crops.—The area under leguminous cover crops was increased during the year, *Pueraria javanica* being the most extensive cover planted.

The following species were in cultivation throughout the year, and seed or cuttings were available for distribution:—

Psophocarpus palustris, Pueraria javanica, Mimosa invisa, Centrosema pubescens, Calopogonium mucunoides, Dolichos hosei, Desmodium scorpiurus, Desmodium triflorum, Aeschynomene americana.

Small blocks placed side by side were established with the main covers for demonstration purposes.

Green manure crops of *Crotalaria anagyroides, Tephrosia candida, Cajanus indicus,* Cowpea, Groundnuts were kept in continuous cultivation, and sufficient areas maintained to supply outside seed orders.

Small demonstration areas of the minor green manure crops such as *Canavalia* spp., *Phaseolus mungo, Tephrosia hookeriana, Tephrosia vogelii, Crotalaria walkeri, Clitoria cajaenifolia, Crotalaria muijussa,* were maintained.

Shade Trees—Windbreak Trees.

The chief temporary and permanent shade tree and shrub varieties used in coffee and cacao cultivation are:—*Crotalaria anagyroides, Tephrosia candida, Leucaena glauca, Erythrina lithosperma, Erythrina glauca, Erythina micropteryx,* and *Albizzia sumatrana.*

Other permanent shade and windbreak trees in cultivation are:—*Albizzia falcata, Adenanthers pavonica, Gliricidia maculata, Peltophorum inerme, Pithecolobium saman, Acacia* spp., *Cassia siamea, Cassia multijuga, Cassia fistula, Cassia grandis, Swietenia mahogani, Hydnocarpus anthelmintica, Bixa orellana.*

Giant Toads (*Bufo marinus*).

In the latter half of the year 1936-37, a number of Giant Toads (*Bufo marinus*) was introduced from Australia with the object of controlling insect pests on the estate. The toads have multiplied rapidly and large numbers are now on the plantation, some have even found their way to nearby estates.

It is interesting to note that for a number of years the *Desmodium triflorum* lawn at the Superintendent's bungalow was severely attacked three or four times a year by cutworms. During the current year, no attack has occurred and this is attributed to the presence of large numbers of *Bufo marinus* which appear to have taken up permanent residence in the garden.

AIYURA HIGH ALTITUDE STATION (5,825 FT.).

General.—At the commencement of this year, the Station was still in its initial stage; as the year closes it presents a secure and settled appearance, with sufficient and effective station buildings, roads and a local aerodrome together with extensive areas under cultivation.

Buildings.—An Officer's Bungalow has been constructed of native materials with window frames and doors of local sawn timbers. Native labour accommodation for 60 labourers has been established, together with a station store and sheds for the storage of locally sawn timbers. All buildings have been constructed of native materials, but with care these should stand for a number of years.

Roads.—During the year, 1¼ miles of station roads have been built; being 12 feet wide and well-drained, these have been constructed with a view towards future development.

'Drome.—In order to save labour and prevent unnecessary loss of time in transporting supplies from Ramu Post, it was decided early in the year to establish a local aerodrome. In all, 64 aircraft have landed during the year. The 'drome itself has been improved until now it provides two runways—one of 750 yards by 75 yards wide, running in a N.W.–S.E. direction, and the other of 400 yards by 75 yards running in an E.–W. direction.

In addition, a 'drome store has been constructed which enables air companies to store their supplies in safety. A wind sox that gives a good indication of the direction and velocity of the wind has been installed.

Cultivation.—Approximately 15 hectares have been placed under cultivation for permanent crops, annual crops, orchard, house garden, &c.

Meteorology.—The rainfall for the year was 78.44 inches, distributed fairly evenly throughout the year. The wettest months were October (10.15 in.) and February (9.65 in.), with the lowest fall in June, 1938 (2.31 in.). The highest daily gauging was 2.28 inches, but such a fall is very unusual. Most rains have been light and steady and have occurred generally at night.

The minimum air temperature recorded was 51.1 degrees F.

Permanent Crops.

Cinchona.—Six blocks each of ½ acre have been cleared in heavy bush country to accommodate the Cinchona series under trial.

These are:—

Amani.	*Bengal.*
1. *Robusta.*	1. *Ledgeriana.*
2. *Succirubra.*	2. *Succirubra.*
3. *Ledgeriana.*	3. *Ledg./Succ.*

The first seedlings from the Ramu nurseries were planted at Aiyura early in 1938 and at the close of the year 2,047 seedlings had been established and transplanted. This work could have been completed if dry conditions in May and June had not caused further planting to cease. Only favorable conditions are needed, and, when these occur, it is anticipated that approximately 4,000 seedlings will be established.

Compared with Java, the losses in the seedlings planted out at Aiyura are not high. Local losses in all varieties amount to 15 per cent. The remainder of the seedlings have struck and are thriving well, now being about 4 feet high.

It now appears certain that, even after a generous allowance is made for further losses in the seedlings still at Ramu nurseries, approximately 4,000 seedlings of three varieties (*Ledgeriana*, *Succirubra* and *Robusta*) and one hybrid (*Ledg./Succ.*) will be established in the field at Aiyura. Although this number is comparatively small, it should serve adequately for seed purposes and for the further establishment in more substantial quantities of all these varieties and afford opportunities for cross-breeding.

In removing seedlings from the nursery, the same technique as applied in Java was employed. That is, all vigorous plants over 3 ft. in height were pruned back and stripped of all leaves. But the roots have not been pruned. Local experience has shown that the Java pruning methods cannot be wisely applied to all varieties. Particularly, in regard to var. *Ledgeriana*, results have been better if the " leader " has been left intact and only the leaves removed. To remove the leaders of small seedlings up to 30 inches in height of any variety has been proved fatal.

In regard to shade, it has been found that var. *Ledgeriana* thrives best under adequate shade, whereas var. *Succirubra* resents it and thrives best under scant shade. The same applies to var. *Robusta*, which under local conditions at least, already has proved itself the hardiest of varieties.

The actual planting of all varieties has been on the 4′/4′ basis. Holes have been dug 18 in. by 2 ft. deep and at planting have been filled with rich soil and leaf mould. The shade materials employed have been *Crotalaria anagyroides* and *Tephrosia Candida*, and where these have not been sufficiently advanced to be effective, artificial shade has been established. *Calapogonium mucunoides* has been established as a cover crop throughout the blocks.

Coffee Arabica.—Blue Mountain.—The 2-acre block necessary to receive seedlings raised from beans received from Wau has been prepared, lined and planted with shade material and the actual planting of these seedlings, now long overdue, will be made as soon as sufficient rain falls in the new year. All seedlings remain in a healthy state in the nursery at Aiyura.

Coffee Arabica.—In March of this year, five varieties of Coffee Arabica beans were received from Kenya. Successful germination was obtained and now approximately 400 seedlings are established of these varieties:—

C. Arabica var. Harari.
C. Arabica var. Columnasia.
C. Arabica var. Maragogippe.
C. Arabica var. Kenya (Drought Resistant).
C. Arabica var. San Ramon.

Cyanide fumigation of this seed was conducted prior to planting.

Tea, British North Borneo.—These seedlings, numbering 179, were transported to Aiyura from Ramu in April last and have been established at this station. Favorable conditions are awaited before these will be planted in the block that has been prepared.

Fruits.—Passiflora edulis (Passion Fruit).—A small block of a quarter of an acre has been planted, the seedlings being planted 10′ 10′. The vines have been trellised and are now bearing their first crop. The results are very encouraging. A plentiful supply of seedlings is now available for general distribution.

Ficus Carica (Fig). Photinia japonica (Loquat). Citrus decumana.—A few seedlings of each have been established in the orchard.

Physalis Peruviana—Cape Gooseberry.—Locally these grow in profusion and produce fruit of excellent size and quality.

Citrus Limonum—Lemon.—Approximately 500 seedlings have been raised locally, and are approaching the stage when they can be grafted or planted in the field.

Castor Oil.—In addition to the local variety established at Ramu last year, three new varieties were placed under trial, viz., Bombay Castor seed, Java Castor seed and Java Castor seed (Brown). In addition, Castor seed received from New Caledonia and India has produced a few seedlings. Adequate seed material is now available for what appears to be a remunerative crop.

Tung Oil.—Aleurites fordii.—Sixteen seedlings have been established in the field, and although these appear to be thriving, it is too early to forecast whether they will be entirely successful.

Root Crops.

With labour and attention required for other more important crops, sweet potatoes were the only root crop established. Approximatcly 3 hectares were planted under this crop, and for the last three months, the station labour has drawn on this supply for food. As local native foods can be purchased from natives at prices not exceeding 15s. per ton, it was considered unwise to concentrate on this crop when other work required more immediate attention. However, an additional 4 hectares of grassland have been cultivated, and will be placed under sweet potatoes after the permanent crops have been planted.

Annual Food Crops.

Maize.—Two varieties—Leamings and Golden Nuggett—were planted, each in half-acre blocks. These blocks have been harvested, satisfactory yields having been obtained. Ample seed material is now available for further, more extensive planting. A small quantity (10 lb.) of Red Nib variety has been received, and this will later be given a thorough trial.

Rodents have been particularly active in their attacks on this crop. Further reference is made to this under a separate heading.

Rice.—Paddy received from the Demonstration Plantation, Keravat, was planted in a half-acre block. The resultant crop has made good growth, but at present has not matured, although a fair yield is anticipated in the initial test on this crop at this altitude.

Indian Corn.—A quarter of an acre was planted in this crop and gave an excellent yield. Ample seed has been retained for further planting, and the balance fed to native labour. In addition, this makes excellent poultry fodder.

Ground-nuts.—Rhodesian.—As previous trials have proved, this variety is outstanding for local conditions, and has been grown to the exclusion of other varieties. One acre was planted, but at present has not been harvested.

Mungo Beans.—A variety trial is being conducted, but the crop is not mature.

Soy Beans.—Otootan.—As the area for crops was limited, and as a substantial quantity was in stock, this crop has not yet been established at Aiyura. But early planting in the new year is anticipated.

Sugar-cane.—The best varieties of local native canes have been collected and planted into a quarter-acre block. As sugar is an important item in local native diet, it is intended to establish a fairly large area under cane.

Cover Crops.—*Calopogonium mucunoides* has been established throughout the *Cinchona and Coffee blocks.* Local seed and cuttings have been used for propagation with equal success.

An acre of bush country has been planted under *Vigna catjang* for native food and green manuring.

A trial of *Tangier Pea* proved successful.

Vegetables.—Successful crops of the following vegetables were grown:—

Peas (Yorkshire Hero).
French Beans (Canadian Wonder).
Carrots, two Yates' varieties.
Cauliflowers, Sutton's Early Market.
Cabbage, Early Market.
Celery, Early White.
Cucumber, Long Green.
Parsnips.
Turnips, three varieties.
Turnip, Swedes.
Kohl-Rabi, Purple.
Onions, Bermuda Red and White; excellent size and quality.
Tomatoes, two varieties; excellent yield with no disease.
Lettuce, three varieties.
Endives, two varieties.
Radishes.
Mustard Greens.

Local seed from most of the above vegetables has been obtained.

Rodents.—The activities of rats, their large numbers and persistent attacks on all food crops, have become serious enough to warrant especial comment. The problem is complicated due to the fact that local natives eat rats even when found dead, and any poisoning campaign, although it would undoubtedly be effective in removing these pests, may lead to difficulties with local natives. Mechanical means of control would appear the only possible alternative, but the numbers captured in this way do not give an effective control. It is hoped that local natives can be trained not to indulge in eating rats found dead, after which a vigorous poisoning campaign can be conducted. This matter has been taken up with the officer in charge, Ramu.

Shade Trees.—An adequate supply of *Leucaena glauca* seedlings has been raised for permanent shade in the Cinchona and coffee blocks.

A successful strike of Eucalyptus Alba seed received from Cairns, Queensland, has been obtained and approximately 200 seedlings are established in the nursery. Likewise, 200 seedlings of *Pseudo Acacia* have been raised. Supplies of seed of *Eucalyptus rostrata* and *E. globulus* and *Acacia decurrens-baileyana* have just come to hand, and will be planted in the nursery shortly.

Reafforestation.—The need for a scheme of gradual reafforestation of the vast grasslands of the highland areas has been emphasized throughout the year. On warm days, natives casually walking about the countryside light fires wherever they may wander. Investigations have shown that this practice locally has no other object than the removal of the grasses so that old enemies can more readily be seen. The idea that the countryside is burnt for rats can be definitely discounted, as any rats caught in the fierce flames are reduced to ashes.

As the year closes, it is pleasing to report that the Administration is likely to take action in arresting this gradual process of deforestation. Mr. McAdam, Forestry Officer, of Wau, has become impressed with the scheme and it is possible that nurseries for raising forest seedlings will be established here in the new year.

A scheme for the actual distribution to local natives of these forest seedlings when produced, and the more important work of establishment and subsequent care of them in the village lands, has been taken up with the officer in charge, Ramu.

Timber-sawing.—In November, 1937, work was commenced on pit-sawing local timbers. At first, progress was slow as indentured labourers had to be trained for the work. But at the close of the year approximately 5,000 feet of various hardwood and softwood timbers were in storage. In addition, 2,000 feet have been used for station purposes. The identity of the timbers selected for use is not known, but up to date four hardwoods and three softwoods have been found suitable for general building construction and furniture. Samples of these woods have been forwarded to Rabaul for inspection.

The timber supply available for this work is considerable. On the present station site, 500 acres of timber country will more than meet station requirements in the future.

Stock Prospects.—The possibilities of stock raising in this area are considerable, and offer great promise.

Various importations of stock to the Ramu area have been made during the year; the number of livestock owned by miners and Mission bodies having been increased by nine head of cattle and approximately 50 goats.

The S.D.A. Mission, Ramu, imported an Ayrshire bull calf of good type, and the Lutheran Mission, Onelunka, eight cows and heifers of Zebu cross.

A campaign against the introduction of cattle-tick has been conducted and all local residents are fully acquainted with the economic losses that must follow if this parasite is introduced. The cattle that have been introduced were inspected on arrival and found to be free of ticks. The District Officer, Salamaua, has given support to the campaign and a local regulation exists which makes an inspection of all cattle imported necessary, before they are admitted to the Ramu area and allowed open grazing. As it is almost certain that all cattle imported will be travelled in via the Lae-Markham Valley and as this station is the first one on the highlands, these precautions appear sufficient.

EXTRACTS FROM A REPORT OF A PATROL TO KUNUA AND HAHON SUBDIVISIONS, BUKA PASSAGE SUB-DISTRICT, KIETA DISTRICT.

By C. F. R. Gilbert.

In the course of the patrol six villages in the Kunua area were visited which had not previously been inspected by an Agricultural Instructor, Kunua and district having only been brought under full control in comparatively recent years. Very few regular coco-nut groves exist, but those that do were found to be clean and bearing well. The natives are still somewhat nomadic in their habits, and until fixed centres are established it might be advisable to defer any planting of coco-nuts on a large scale, as maintaining the areas in a satisfactory condition would present serious difficulties.

Several of the village officials at the more permanent centres appeared keen to plant coco-nut groves, and in these cases advice and instruction as to proper planting and spacing were given.

In the Hahon area, which has been permanently settled for some years, the groves, with few exceptions, were found to be clean, but it was obvious in many cases that this had only been done on the approach of the patrol, and had apparently been neglected for some little time past.

The palms in many cases were showing poor growth and not bearing well owing to having been badly planted in soil of a stiff clayey nature, and also probably due to neglect in the early stages of cultivation. In several villages where the palms had been well planted and cared for they were observed to be healthy and bearing well. All the well-known coco-nut insect pests common to the districts were found throughout both areas, but not in large numbers, although collections were taken at almost every village.

The main food crop of the natives of Kunua and Hahon is taro (*Colocasia esculenta*), supplemented by yams (*Dioscorea*) and bananas (*Musa sapientum*), and generally the gardens were found to be very satisfactory. Each village also had its quota of small patches of tobacco (*Nicotiana tabacum*).

The coastal belt extends up to 3 miles inland and contains several areas of volcanic soil with a good proportion of humus, the balance containing intermediate to rich loamy soil and sandy loam with humus. Numbers of clear running streams pass through these areas, but owing to the shifting sands at the mouths usually form into swamps near the sea shore.

Beyond the flat coastal belt to the east, the mountains rise fairly sharply and not more than a few acres sufficiently flat for commercial cultivation would be found. In this area the soil generally is argillaceous with a shallow surface of sandy loam on the slopes and rich humus in the valleys.

Apart from the cultivation of coco-nuts, there are certain areas which would be very suitable for the cultivation of cocoa (*Theobroma cacao*) and tobacco (*Nicotiana tabacum*). Labour would present little difficulty, as recruits could be obtained locally.

There is no harbour or safe anchorage south of Soraken and shipping would be a problem except in very fine weather. Soraken is a shipping point which can be used in all weathers, and it would be possible for a road to be constructed along the level coast line, but a number of bridges would be required. As the bulk of the native population is established further inland in the mountains, there are large areas in this coastal belt which could be taken up without causing them any hardship.

FROM PLANTER TO PRIME MINISTER.*

An article headed as above, from the pen of Mr. C. Ward-Jackson, appeared in the issue of the *Malay Mail* dated 20th October, 1938.

Realizing the special interest such an article would have for planters, Mr. Ward-Jackson has been good enough to amplify his article, by sending to us the following letters from Mr. Chamberlain, showing in close detail the sort of life the Prime Minister led as a planter.

In a letter written in 1890, he said—

"At 5 o'clock I get up, and after a cup of tea go down to the field, which is about three-quarters of a mile off. There I superintend the landing of lumber, and direct the men who are at work clearing. Sometimes, I take an axe myself, and do a little work, and this creates great enthusiasm. About 9, I go back home for breakfast, and then return to the field, where I have my lunch sent me at 1. At 4, I stop, go home to tea, after which life becomes unbearable by reason of the millions of mosquitoes, which necessitate the burning of 'trash' on the house floor until I go to bed about 8."

Here is the text of a letter written by him in 1894—

"Last week was one of the most severe I have ever had. On Friday, as if I had not enough to do otherwise, three schooners arrived with provisions and plants. Yesterday, as I had expected a heavy day's work, I told Arden to come and help me in the office, but early in the morning a vessel arrived with sisal leaves. From morn to dewy eve, I toiled away, not even stopping for lunch. By common consent we never had so many people here before. Another schooner arrived full of plants, and a vessel from the south end of the island full of people who brought island produce to sell, and wished to buy American provisions. About 9 o'clock in the morning Cash came to me for whisky, saying he felt faint. I had to take him up to the house, and leave him there all the rest of the day unable to do anything. Knowles and his whole family went off in the middle of the day to recruit, and a little later Johnson, the circuit magistrate, came to pay me a visit. Of course, being everywhere short-handed, the shop became absolutely packed. I had to go in myself, and lend a hand. We only served the bare necessities of life, and then shoved the people out by main force. Late in the afternoon another vessel came with leaf, and this morning yet another has come full of plants. The wharf was already piled high from end to end and the carts must be used for taking out leaf which cannot wait. Is not all this enough to turn one's hair grey? That mine has not is attested by the fact that my cash balanced exactly last night in spite of innumerable entries and cross entries, additions, and subtractions, heat, mosquitoes, and crowds of people."

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* From *The Planter*, Vol. XIX. No. 10, October, 1938, p. 489.

COCKROACHES.

Disease to Humans.

There is no evidence to support the belief that cockroaches convey disease to human beings, it was stated in a health talk from the British Malaya Broadcasting Corporation station.

In Malaya the favourite breeding places for cockroaches are septic tanks which have not been properly sealed, and covered drains, it was stated. In both situations they are able to hide in a dark, humid atmosphere with plenty of food close to hand.

For this reason drains should never be covered over and septic tanks should be tightly sealed. If troubled with these pests it is always advisable to inspect the drains and the septic tank.

Traps baited with stale beer or pieces of peeled banana are of considerable use and can be made quite easily from jam jars or tin cans.

A cone of paper should be made and the tip of the cone cut off. The cone is then placed in the top of the jar or tin, after the bait has been placed point downwards so that once the cockroach has slid down the cone and entered the tin, it will have great difficulty in getting out again.

A piece of wood or cardboard should be placed to form a stairway from the ground to the rim of the jar or tin, so that the cockroaches can get to the top with ease.

A useful insect powder for use against cockroaches is three parts of sodium fluoride mixed with one part of powdered pyrethrum. This powder should be scattered about at night in the kitchen and other haunts of the cockroaches and swept up next morning.

The sodium fluoride is the important ingredient as it acts as a poison to the cockroaches. There are a number of cockroach powders on the market which contain sodium fluoride.

Powdered borax is also useful but it is not of much use to put it under the paper linings of drawers and cupboards. What we want to do is to persuade the cockroach to eat the borax and the best way to do this is to mix it with fine sugar or with powdered chocolate.

Borax can also be mixed with treacle and the mixture spread on pieces of tin or cardboard. The important thing is to mix the borax with an attractive food and to leave the mixture lying about in the cockroaches' favorite haunts.

Spraying cockroaches with a liquid insecticide is also of use, especially where the insects can be trapped in a cupboard or box.

The cockroach is found in all quarters of the globe and is important because of the damage that it does to food. It is not so much the quantity of food that it eats but the amount it spoils.

Besides spoiling food by fouling it with its excreta it taints everything with which it comes into contact. The "cockroachy smell" that it imparts to food and clothing is due to certain chemicals in its saliva and to a wax which is secreted by scent glands in its body.

The cockroach will eat anything from the whitewash on the wall to the best food in the house. It is especially fond of curry-stuffs, sweet foods and beer. It does considerable damage to boots and shoes and to books, especially the binding. It eats gum and paste with avidity.

Clothing is also attacked, especially if it is even slightly soiled with food.—*Straits Times,* 27th December, 1938.

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THE SWEET POTATO HAWK MOTH.

Hippotion celerio.

(*By John L. Froggatt, B.Sc., Entomologist.*)

This pest was referred to in a previous issue of this *Gazette*,* but further information has been obtained on certain aspects of the problem, which it is proposed to bring forward in reply to various inquiries recently made in connexion with its depredations.

The adult moth measures about 2½ inches across the outspread wings, of which the fore pair are brown with whitish lines and the hind pair reddish with dark markings. They are very swift fliers, and normally only move about at night; they are rather attracted to light.

The eggs are laid on the foliage and take three to four days to mature. The young grubs feed from the under-surface of the leaves and are light green in colour with a dark spine projecting upwards from the back at the anal end of the body. (This spine is a characteristic feature of the caterpillars of this group of moths.)

The full-grown caterpillars are 2–2½ inches in length, and vary in colour to almost black. During the last three days of their development, a much greater quantity of foliage is consumed than in the earlier periods.

When feeding is completed, the caterpillars burrow into the soil to transform into the chrysalis, which is a resting stage. The caterpillars take 10–12 days to reach maturing and the chrysalis occupies 15–18 days, before the adult moth emerges. As the moths die very quickly in captivity, the life of the adults has not been determined.

The incidence of this pest varies markedly with the seasons, often becoming a serious pest during dry weather conditions.

Insect Parasites and Predators.

The maggots of a fly, *Carcelia kokiana*, Towns (*Tachinidae*), are a parasite of the caterpillars of the sweet potato hawk moth, and are at times very numerous.

The adults and nymphs of a bug, *Platynopus malacanthus*, Boisd, (*Pentatomidae*) have been collected when feeding on the caterpillars of *H. celerio*.

Other Predators.

Bufo marinus, the giant toad, has been introduced in an attempt to cope with this and other pests.

Fowls and ducks will not apparently eat the caterpillars.

Mechanical Measures.

Spraying with *arsenate of lead*, 1 lb to 50 gallons of water, or dusting with 10 per cent. *arsenate of lead* or *calcium arsenate*, will control the pest if carried out as soon as the caterpillars are seen or the moths are observed to be laying eggs.

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* Vide *New Guinea Agricultural Gazette*, Vol. 2, No. 1, January, 1936, page 13.

In normally fine weather, three treatments at intervals of about ten days should be sufficient, but heavy rain after dusting or spraying will necessitate further treatments. Dusting is best carried out in the early part of the morning, while the dew is on the foliage, when a better adhesion of the dust is obtained. The nozzle should be depressed so as to drive the powder downwards.

Spraying necessitates the use of an end piece and nozzle that will enable the spray to be directed on to the underneath surface of the foliage.

Light Traps.

As these moths are attracted to light, a trap can be made as follows:—Make a shallow pan (e.g., bending up the edges of a sheet of galvanized iron), fill it with water and cover with a film of kerosene. In the middle stand a lamp with a strong light surrounded with a light framework over which thin white lava-lava or calico is tightly stretched. This can be set out in the area under crop at night soon after dark. The moths coming to the light fall into the water and are drowned.

The only disadvantage of these traps is that beneficial insects may also be killed.

Other Hosts.

Taro (*Colocasia* spp.) and *Caladiums* are at times severely attacked by this pest, the foliage being stripped to the midribs of the leaves.

COCKROACHES AND THEIR CONTROL.

(*By John L. Froggatt, B.Sc., Entomologist.*)

These household pests are nocturnal in habit, hiding in any dark crevices, corners or cupboards during the day, and coming out to feed at night. Kitchens are particularly favoured by the attention of these obnoxious insects, but by carefully locating any sheltering sites are fairly easily treated.

The most satisfactory chemical for killing these insects is *sodium fluoride,* a white powder. Although poisonous to humans, if taken internally in sufficient quantity, provided reasonable care is taken in its use, the risk of contamination of foods is negligible.

The best method of reaching the cockroaches is to dust this powder into crevices by means of a small blow-gun or bellows, or scatter it on the floor and shelves of cupboards. The insects pick up the powder on the legs and antennae (" feelers ") and, in order to clean off the powder, drain these members between the mouth parts; by this means the poison passes to the stomach and kills the insects.

In dry situations, the powder remains more or less indefinitely, but where subject to moisture, it is liable to cake and become useless. In such cases, it may be advisable to blow the dust into the hiding places once a week at least.

Another matter that should receive careful attention is the masses of eggs. These are enclosed in a brown capsule about half an inch long and rounded on the ends; the outer side is often covered with a white mealy-like powder. These are placed in cracks along wainscotting, crevices, behind doors, &c. Wherever found, they should be destroyed, as each capsule contains a number of eggs.

As cockroaches breed in heaps of decaying leaves, &c., care should be taken to turn over periodically any heaps of garden rubbish, &c., in the vicinity of dwellings.

VETERINARY SCIENCE NOTES.

Lameness in the Horse.

(*By I. J. L. Wood, Q.D.A.*)

The following notes may be of interest to horse-owners in the Territory:—

Lameness is the most common ailment of the horse, and is responsible for about 75 per cent. loss of service.

The majority of cases of lameness is due to either careless or wrong methods of handling, and, thus, a large proportion of loss of services is preventable.

Lameness may be defined as a visible symptom of pain, and at least 80 per cent. results from injuries below the knee and hock, although to the average layman the common seat is located in the shoulder. In actual fact shoulder lamenesses are very rare.

It is marked in progression by definite symptoms commonly known as dropping, indicated when the forequarters are affected, by a lowering of the head and a dropping of the shoulder when the non-affected limb contacts with the ground. When in the hind limb, dropping occurs in the opposite hip to the affected limb.

Horses at rest show signs of pain in the limb by what is termed "pointing". This refers to the position in which the affected limb is held. Where the trouble is below the knee, the foot is usually carried slightly forward; when above the knee, the limb is slightly flexed with the toe resting on the ground slightly behind its fellow.

Lameness may be divided into two classes—

(1) Those due to traumatic causes, i.e., wounds and bruises.

(2) Those due to bony unsoundness.

(1) Most cases of lameness are due to wounds, injuries and muscular strains. They are rarely serious and usually respond to the treatment of rest for a few days.

Most strains result in the presence of slightly increased heat in the part and soreness when moved or palpated.

To relieve, apply a cooling lotion and then give absolute rest for a few days. After all inflammatory changes have been reduced the application of a mild stimulant or blister over the part will stimulate the blood supply and hasten recovery.

(2) Perhaps more important than the muscular conditions are those arising from what are termed bone diseases. The common bone diseases are splints, ringbones, spavins and sidebones, though the latter is not truly a bone disease.

Splints.—These are bony enlargements which form between the small and large metacarpal or metatarsal bones. They may form anywhere throughout the small bones, but are usually found in the "middle third". Occasionally, they develop in the vicinity of the knee joint and are then known as high splints, a type which is usually difficult to treat successfully, owing to its proximity to the joint.

Splints are due to concussion. A common cause of splints is coarseness of bone and bad conformation by which concussion is not evenly distributed. Where horses are shod, splints may occur in perfectly developed bone and correct conformation as the result of bad shoeing.

As the result of the concussion, irritation is set up beneath the periosteum causing an exudation of fluids which press on the nerves lying within the periosteum. At this stage, a splint is painful, particularly at the trot. In course of time, the fluid is impregnated with mineral matter, converting it into bone tissue. Usually, by this time, all symptoms of pain have ceased.

Treatment.—First, rest, with applications of cooling lotions to the affected part. When the inflammation is reduced, use a strong blister compound—one part of biniodide of mercury and four parts of lard or vaseline. The area immediately over the splint should be clipped, then well washed with water and soap to cleanse the pores. A small quantity of the blister should be applied immediately over the enlargement and rubbed into the skin for about ten minutes, after which any surplus blister should be removed. Then surround the area on the sides and beneath with vaseline or lard, thus restraining the action to the desired area. Next tie the animal's head up short and keep it tied up until the blister has ceased to act, usually 5–6 hours. Unless the head be tied up short the animal will endeavour to bite the area, resulting in a blistering of the mouth and tongue. After the action has ceased, wash the area with warm water and soap and then apply grease. This will prevent sloughing of the skin.

Ring Bones.—A bony exostosis occurring on the Pastern bones and interfering with the movement of the joints. When the exostosis involves the Suffraginus coronae articulation it is known as a high ring bone; when the Coronae pedis articulation, a low ring bone. The latter is generally difficult to diagnose, as the area is within the upper border of the wall of the foot.

For ring bone there is no known treatment of curative value. Ring bone is classed as one of the hereditary unsoundnesses believed to be due to faulty conformation.

Spavin.—An exostosis involving the hock joint. The usual situation is the antro-internal aspect of the hock.

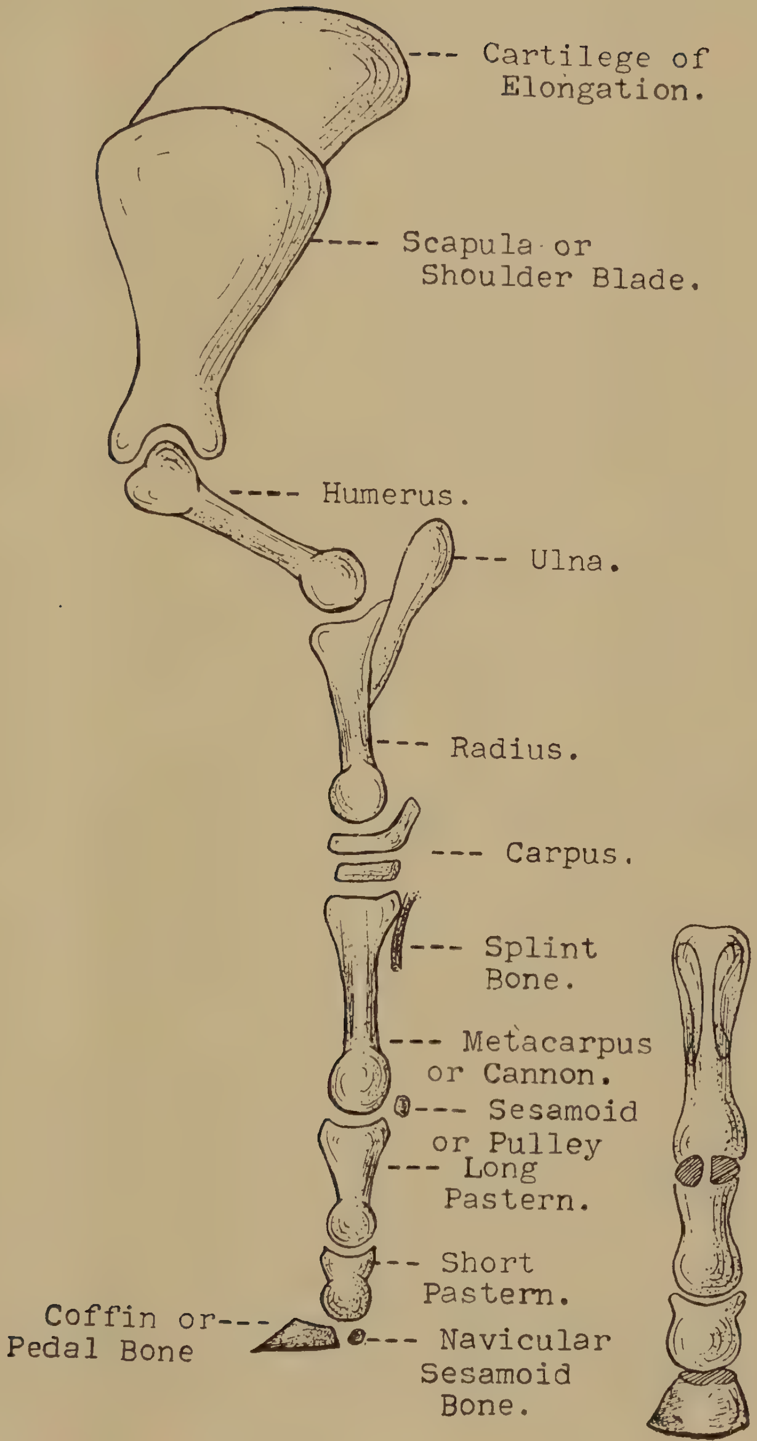
Occasionally the position occurs between the bones without external manifestations. This is known as an "occult spavin", a variety which can only be diagnosed by action. An animal suffering from spavins does not carry the limb forward to the full extent and the toe strikes the ground at the end of the movement.

There is no curative treatment. Blistering the affected part relieves the painful stage.

Side Bones.—An ossification of the lateral cartilages situated in the upper border of the wall. Similarly to ring bones and spavins, side bones are classed as hereditary unsoundness. Normally this cartilage should be soft, elastic and springy under pressure. As the result of the inflammatory discharges becoming impregnated with mineral matter, an animal affected with side bones will quickly go lame on roads with hard surfaces, particularly at fast speeds. With ordinary riding on grassed tracks, an animal with side bones rarely suffers inconvenience or lameness therefrom.

Fore limb bones comprise—

The *scapula* or shoulder blade.
Humerus, radius, ulna, carpus (eight small bones).
Metacarpus (one large and two small bones).
Pasterns (3)—*os-suffraginus, os-coronae,* and *os-pedis.*
Immediately behind the fetlock joint are two small oval bones (*sesamoids*), and behind the *os-pedis,* the *naviculae.*


Cartilege of Elongation.
Scapula or Shoulder Blade.
Humerus.
Ulna.
Radius.
Carpus.
Splint Bone.
Metacarpus or Cannon.
Sesamoid or Pulley
Long Pastern.
Short Pastern.
Coffin or Pedal Bone
Navicular Sesamoid Bone.

CLIMATIC NOTES ON NEW GUINEA.

By B. G. Challis.

It is noted that throughout the Territory an increasing interest is being taken in the weather and climate of New Guinea, and for the information of residents generally it is proposed to supplement the attached climatological tables with a few notes on the subject of meteorology as it affects the Territory.

Meteorology may be defined as a study of the atmospheric conditions and its various changes, or, being a branch of the wider science Physics, it is sometimes referred to as the science of the earth's atmosphere, embracing both weather and climate. The study of the latter, however, is separately designated climatology. Climate implies the degree of heat, light and moisture, and affects the suitability or otherwise of a country for vegetable, human or animal life.

With the introduction of scientific methods in industry and commerce, applied meteorology is, of recent years, rapidly coming to the fore and, thus, we have sub-divisions as agricultural, marine, aeronautical and insurance meteorology. From time to time, as circumstances permit, these branches of meteorology will be dealt with through the medium of this *Gazette*.

The following notes, however, deal in a general way only with climatic conditions as met with in the Territory of New Guinea, and readers are cordially invited to communicate with the Department of Agriculture, Rabaul, regarding the weather conditions which they may experience from time to time, so that more detailed information may be collected and more accurate climatological data be made available for the benefit and interest of the Territory generally.

The Mandated Territory of New Guinea is situated 141° to 156° east longitude, and approximately 0°–8° south of the equator and, as its latitudes imply, a typically tropical climate in the narrower sense is experienced, although nothing like the climatic fluctuations which occur between 8° south and 23° south.

To those who have never lived in the tropics, the word "tropics" very often conveys a wrong impression of the actual conditions to be expected. This is perhaps due to the term "temperate climate" applied to the intermediate zones either north or south of the equator, where extremes of temperature, ranging from as low as 0° Fahrenheit to as high as 125° F. are liable to occur. (125° F has been registered at Bourke in New South Wales.)

The tropics are generally defined as ranging from 23° north on the tropic of Cancer to the tropic of Capricorn at 23° south of the equator, but, from a practical geographic point of view, the "tropics" may better be regarded as lying between 10° north and 10° south of the equator, and in these latitudes within which New Guinea lies in the Southern Hemisphere, the temperatures at sea level seldom rise higher than 95° F. or rarely sink below 70° F.—figures which indicate a more temperate climate than those experienced in the more popularly recognized temperate zones with their extreme range of weather conditions. However, as in temperate climates, the temperatures in the tropics are affected by elevation by a drop or lapse rate of about 3° F. in every 1,000 feet of altitude; Humboldt,(4) the great German explorer, discovered that the thermometer fell 1° for every 343 feet of elevation, a fact which is evident by comparing the 1938 tables of climatological stations at Bulolo, 2,200 feet, Aiyura Agricultural

Station, 5,875 feet, and those of the coastal districts capital stations. It is interesting to note that aviators have reported ice accretions on aircraft at 16,000 feet when in flight over the mainland of our Territory, but on descending to about 14,500 feet such ice formation disappeared. Falls of snow have been reported on Mount William (approximately 15,000 feet).

The situation of the many islands which comprise the Territory permits of a free circulation of air so that, from a general point of view, the climate resembles that of the ocean near the equator, i.e., with high average temperature and stable atmospheric conditions, and thus we have along the coastal belts, a maximum isothermic average of about 88° F. and a minimum average of 75° F. and a mean of 82° F. It will be observed that there is little seasonal variation between the cooler and warmer months. The range being about 3°.

In the Territory there is no winter with its short days and long nights, or summer days of a converse nature. The sun daily ascends and descends almost perpendicularly with the horizon, so that dawn and twilight are of short duration. There is but little apparent change in the sun's position daily at noon, when the sun stands practically overhead, and, in consequence, there is only a small daily temperature variation, and only about half an hour difference between extreme times of sunrise and sunset, during the course of a year.

Slight variations in temperature become distinctly noticeable to acclimatized tropical residents, despite the small temperature range. There are other atmospheric conditions, such as humidity, which affect the human senses, but there is no fear of heat wave visitations such as were experienced in Australia during the last summer, when high record temperature registrations were reported in most States.

Actually New Guinea, with its widespread area of 93,000 square miles ranging from the large mainland area with mountain peaks of about 15,000 feet to numerous islands of diversified shapes and sizes, presents many climatic variations, but broadly regarded, along the coastal belts, where most Europeans are settled either in business or agriculture, the climate is hot and moist; whereas in the mining settlements of the highlands weather conditions are cooler and more pleasant. In the plain country, there is a greater range of the minima and maxima temperatures which is doubtless due to greater radiation. There is, however, that "everlasting sameness" which has an enervating effect on the populace, but this can be combated with attention to suitable diet and a moderate amount of exercise.

Weather conditions as affecting man in the tropics have been comprehensively dealt with by Dr. Douglas H. K. Lee(5) in a series of articles, entitled *The Tropics and Man* which appeared last year in the *Queensland Agricultural Journal,* and these observations are applicable to New Guinea.

Generally speaking, our calendar year is divided into two seasons which correspond to the periods in which the south-east trade winds or the north-west monsoons prevail. Fortunately, New Guinea is outside the hurricane zone. Squalls are often experienced, especially during the north-west monsoon period, but it is thought that there is a tendency to exaggerate their intensity by European residents who are accustomed to more open-air housing conditions than they may have known in other countries.

WINDS.

Changes in Weather Conditions.

Although New Guinea has nothing that can be described as summer or winter, there are changes in weather conditions, due sometimes to general and sometimes to local causes.

Local Causes.

Land and Sea Breezes.—The local cause is attributed to gravity winds, sea and land breezes. Land and sea breezes are felt only along the coastal areas of the larger land masses throughout the islands.

The explanation of the local breeze is that as the day progresses and the sun shows itself above the horizon, the land becomes warmer more rapidly than the adjacent sea, owing to the sun pouring down a stream of radiant energy or insolation, which on contact with the land manifests as heat and causes a rise in temperature. The land surface being a better absorber than the sea surface, it is naturally a better radiator of heat when subject to the same amount of insolation, so that in the mornings the air above the land becomes warmer than the air above the water. The warm air then rises, and is replaced by damp and denser air flowing in from the sea, and this particular indraft of air is known as a sea breeze. As this incoming air in its turn rises, it cools and its moisture condenses to form heavy cumulus clouds. Towards sunset, the reverse process of air flow takes place through the sea losing its radiation more slowly than that of the land. This results in upward convection currents over the sea due to its lessened density, thus setting up a land breeze, and the cooler air from the mountains descends to the sea where it becomes warmed again, thus preserving the equilibrium unless the monsoonal or trade winds cause a change in this sequence.

The configuration and vegetation of the land in some portions of the Territory have a marked effect on the development of land breezes and, unless a considerable land mass is adjacent from which radiation can emanate, it is unlikely that local winds will form to any extent.

Land and sea breezes are most noticeable off the mainland, and the islands of New Britain, Manus, New Ireland and Kieta.

Land and sea breezes seldom reach a height beyond 1,500 feet or attain a velocity above 10-15 miles per hour, nor do they extend their influence inland, nor beyond about 12 miles or 10 miles out to sea.

Gravity Winds.

Gravity winds are perhaps best known in the Markham Valley and other parts of the mainland ranges, but they are also prevalent in other parts of the Territory where high mountain ranges are also in evidence, such as Kieta, which has Mount Balbi, 10,170 feet, New Britain–Ulawun (The Father), 7,546 feet, and Mount Bamus (South Son), 7,376 feet. The intensity of these winds will of course be influenced by the relief features of the land.

The gravity winds are purely local winds and often bear no relation to the distribution of the general atmospheric pressures.

During the day, the sun warms the ground in the valleys and an upward flow of air is commenced due to the convection of heated air. As the air in the valleys becomes warmed, its density decreases and as heated air rises, it flows up the valleys of mountain slopes in the form of an *Anabatic* wind.

At night the reverse process occurs, and a different wind called *Katabatic* is experienced in the hills.

Particularly on clear nights, the radiation from the ground is greater on the mountain tops than in the valleys, because at the higher altitudes there are less dust particles and water vapour particles in the air to intercept the radiation and thus to absorb or reflect it. Hence, we find that the air on the surface of a hill is colder than the air at some distance from the surface, and as it is colder air, and, therefore, denser at the tops of the ranges, a flow of air will gravitate in the direction of the slopes to form a *Katabatic* wind. Under favorable conditions, such as the augmentation of the seasonal winds, these gravity winds develop quite high velocities, but generally they are quite mild.

Upper Winds.

At present no data is available on the upper winds of New Guinea, although experiments in this respect are now being conducted by the aid of pilot balloons at Salamaua and Rabaul.

The opinion at present held is that above the local winds, the trades and monsoons prevail, whilst above the seasonal winds, the direction of the winds is reversed to preserve the general atmospheric wind equilibrium.

Lull of Wind at Night.

Normally, we experience a lull in the wind after sunset and until sunrise. This drop in the force of the wind is not in evidence far out to sea nor above about 1,000 feet.

The lighter winds in the evening are a result of lack of heating from the sun's radiation. This does not allow for convective rising and mingling of the lower layers with the upper, and these lower layers therefore do not receive any impulsive force from above.

During the day the opposite effect is in operation. The sun's radiation heats the lower layers of the atmosphere by convection, and these rise and become connected up with the upper layers, which exert a driving force on them thus increasing their velocity which, were it not for the friction of the ground, would approximate closely to the velocities in the upper layers.

It is of course assumed that there is a steady wind blowing in the upper layers, which is not always the case as in the months of change of season, but it is true for the major parts of the year, during the north-west monsoon and south-east trades.

This lull in the wind is more noticeable during nights of clear sky when the clouds cannot cause a blanketing effect, and prevent free radiation from the earth's surface. On clear nights, radiation from the earth is greatest and thus cooling off is greatest. Under such conditions, the density of the air in contact with the earth's surface increases, and this greater density means a greater lulling of the wind.

The velocity of the wind at the earth's surface is usually greatest in the early afternoon, and least before dawn, but, at the tops of hills, the reverse conditions generally operate.

Seasonal Winds.

Whereas land, sea and gravity winds are local in origin and develop daily within confined, limited areas, the seasonal winds of New Guinea are felt more generally. They divide the year into two seasons and are classified as the north-west monsoon which blows intermittently from December to April, and the south-east trades which prevail from about the end of April to early November,

Sometimes these seasonal winds are referred to as monsoons.(6) "Monsoon" is derived from the Arabic "season", but strictly speaking, monsoons are restricted to Southern Asia and the East Indies where the word monsoon is often used to denote the "rains", more especially the rains which accompany the south-west seasonal winds in those parts.

Monsoons are caused by the seasonal difference of variation of temperature between land and sea areas, and change with the summer and winter of the temperate zones of Southern Asia, where exceptionally high and low barometric pressures operate in summer and winter respectively. In New Guinea, there is very little variation in temperature or barometric pressure throughout the year, and the only monsoonal wind felt is when the north-east monsoon off Southern Asia is deflected into a north-west wind during its passage across the equator, and blows intermittently until its strength is lost in the doldrums—the zone of calms and light variable winds which move north and south of the equator with the annual change of the sun's declination.

The change in the direction of this north-east monsoon off Southern Asia is accounted for by the fact that the earth's velocity at the equator is about 1,000 miles per hour from west to east with an easing off to zero at the North and South Poles. This action gives effect to Professor Buys Ballot's(1) Law which states that—"If in the Northern Hemisphere you stand with your back to the wind, the wind pressure is lower on your left hand, but if in the Southern Hemisphere you stand with your back to the wind, pressure is lower on your right hand".

The more prevalent seasonal wind in New Guinea is the south-east trade—a name originating in the days of sail "to blow trade", meaning to blow constantly in the same direction. This nautical phrase was subsequently shortened to the word "trade".

It is of interest to note that the monsoons were formerly grouped with the trades.

The trades circulate from the great permanent oceanic high pressures at 30° north and 30° south of the equator, and these characteristically regular trades encountered in this Territory sweep up from about latitude 30° south during the winter season of the Southern Hemisphere. Similar trades blow from the north during the winter of the North Hemisphere, but the Indian Ocean and China Seas are exceptions to this general rule and it is from the last-named direction that our north-west monsoons are derived.

The trades are supposed to be constant in force, but closer observations reveal that they are variable when interrupted by contact with the land masses with their local winds and other atmospheric influences. It is generally recognized in meteorological circles that although throughout the Pacific Oceans, the south-east crosses the equator during the summer of the Northern Hemisphere the north-east trade does not extend to the south of the equator. As New Guinea lies in the southern latitudes, the names given to our seasonal winds are the north-west monsoon (December to April) and south-east trade (May to November).

Both of these seasonal winds carry moisture but the degree of precipitation which occurs is regulated by the height and situation of the land which they strike en route. The rains very often fall in more violent showers than in the more temperate latitudes. The physical features of New Guinea being so varied they account for the diverse monthly and annual rainfall averages shown on the rainfall map. While the seasonal winds are blowing strongly, they overcome the land and sea breezes, but if only blowing moderately, the land and sea breezes will cause a small daily variation in the strength and direction of the seasonal winds near the coasts.

South-East Trades.

As previously mentioned, the south-east trades prevail throughout the Territory from May to November. They make their appearance about the end of April, and gradually increase and freshen in force until July, when the winds continue with marked regularity until October. Their force is then abated by the presence of the north-west monsoon which at this period begins to assert itself against the trade in the upper layers, thus causing the calms experienced during November and correspondingly around April with the change of seasons.

Wind roses have not been prepared to indicate the strength and direction from which the various winds blow, but it is recognized from general observations that in the Admiralty Group and along the north coast of the mainland, so far as the south-east trade is concerned, its strength is more intermittent in character while its course is deflected in such places as St. George's Channel, Dampier and Vitiaz Straits, where it follows the trend of the land, which thus gives it a more southerly direction.

Where the orographical features permit, as in the Huon Gulf and south coast of New Britain, there is a particularly heavy rainfall during the period in which the south-east trade prevails.

In July, when the south-east reaches its maximum intensity, the wind sometimes blows strongly for stretches up to a fortnight. In crossing the New Britain ranges much of the moisture content is lost on the southern side of the island, but the wind continues with but little lessening in force as far as the Admiralty Islands. It merges in the Doldrums, just north of the equator.

The weather is perhaps a little more hazy during the south-east season.

North-West Monsoon.

The north-west monsoon is of a more intermittent character than the south-east trade and blows with more sudden squalls, and often brings more rain, although it will be noted that in the more exposed islands, the rainfall is fairly regular in most months of the year.

The presence of the north-west monsoon is first felt in the northern part of the Territory in November, and its influence is gradually extended southwards until about Christmas time when it may be considered to be general throughout the islands. There is considerable variation in the strength and direction of the winds during January to March and unsettled conditions and heavy rains are frequently the order of the day. It should be noted, however, that along the Finisterre Range south-east from Madang, in the Huon Gulf and on the south coast of New Britain, this is considered to be the dry season, because in these parts it is found that the north-west monsoon is less effective.

Change in Seasons.

The change in seasons usually covers a period of five or six weeks between April-May and November-December when either the monsoon or trade wind is losing its force, and neither wind has full charge of the higher atmospheric movement. At such times the weather is generally more humid and oppressive, and thunderstorms in the afternoon often occur.

Along the coastal areas the early morning skies are often clear or have high cirrus clouds. By about 9 a.m. to 10 a.m. cumulus or cauliflower-shaped clouds form and continue to develop until the afternoon, when very often thunderstorms are likely to occur. Thunderstorms also occur out to sea, and are more generally found to occur in the early hours of the morning, due to night radiation from the cloud tops, but are usually later in breaking out than over the land.

It has been found that the electrical potential in the region of lofty mountain peaks is often very high. Increase in electrical potential is recorded where the warm air from the sea coast, carrying dense masses of water vapour from the sea, is forced up the high mountain slopes, and the electrical charge increases with condensation. Thus there would be more liability to lightning near very high mountains (e.g. lightning strike in coco-nuts is particularly severe at the foot of Mt. Balbi, 10,170 feet, Bougainville Island). Although under moist conditions, the potential need not be so great as in a dry atmosphere, the exaggerated causes here due to altitude are more pronounced in the tropics. Of course, other factors may cause particular areas to be liable to severe lightning storms.

Frequently between 9 a.m. to 10 a.m., the seasonal winds which have abated during the night, begin to blow again to some degree, although it should be noted that they often blow throughout the upper air layers during the night. Where there is so often a comparatively clear sky in the mornings, as already mentioned, places with an eastern exposure receive more sunshine compared with a similar position to the west.

Pressure.

In the winter of the Northern Hemisphere the average pressure is very high over Asia and the North Pacific while at the same time there is a corresponding low in Australia. In the summer of the Northern Hemisphere the pressure distribution is reversed. New Guinea lies practically between these defined pressure zones, but being subject to tropical oceanic conditions, there is very little isobaric change along the coast, although a slight increase is noticeable in the transition periods of the Asiatic and Australian pressure zones.

At mean sea level within the Territory the average pressure differs little from about 1008.5 millibars or 29.78 inches and 3.5 millibars would cover the range between highest and lowest monthly average values.

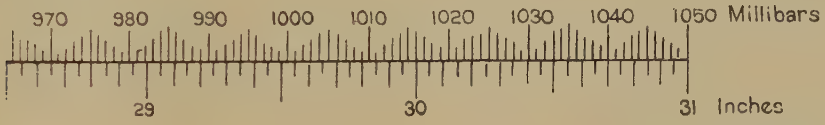
Twice daily there are rises and falls in the barometer. At 9 a.m. and 10 p.m. it reaches its highest and at 4 a.m. and 4 p.m. isobaric pressure is lowest. Any departure from this diurnal variation may indicate a change of weather.

Where there is a defined wet and dry season, as in Rabaul, the average monthly pressure is higher in the dry season than in the wet. It will be noticed that the morning maximum is often higher in the dry season while in the wet season the evening maximum shows a tendency to be more pronounced.

The greatest difference between highest and lowest barometer readings for Rabaul last year was 10.2 millibars or 3/10ths of an inch.⁽⁸⁾ With such small variations it will be seen that aneroid barometers are of little assistance to weather observers in this Territory and that extreme accuracy is necessary in reading mercurial barometers if any value is to be placed on such registrations.

Pressure and Winds—Barometer.

The accompanying diagram shows the equivalent of millibars in inches, and vice versa:—



Humidity.

Frequently this office is called upon for an explanation of humidity. Apparently the relative humidity figures which are published each week in the local press are often the cause of comment on this subject.

Humidity is commonly expressed in relative figures, hence the term *relative humidity,* by which is meant the amount of moisture or water vapour actually in the air to the amount it would have if saturated at a given temperature, or in other words, the air is a certain percentage saturated with moisture. This amount is determined from the readings of the thermometers known as the "dry and wet" bulbs, erected in the shade 4 feet above the surface of the ground, where there is free circulation of air.⁽³⁾

The dry bulb (an ordinary thermometer) shows the internal shade temperature of the air, while the wet bulb indicates the external shade temperature of evaporation. The wet bulb is an ordinary thermometer kept covered by wet muslin (changed at least once weekly) attached to a reservoir of distilled or rain water by strands of absorbent cotton thread, which keeps the muslin supplied by capillary attraction. Since evaporation causes cooling, the reading of the wet bulb is lower than that of the dry bulb, unless the air is saturated, or it is raining, in either of which cases evaporation is no longer possible.

If the wet bulb records over 80° F. the weather is exceedingly trying and should it reach up to 88° F., it is regarded as prejudicial to life.

Wet bulb registration above 80° F. may be regarded with suspicion, and correct readings over 88° F. are practically impossible.

The drier the atmosphere the greater will be the difference between the readings of the wet and dry bulbs. It may be as much as 30°, if there is very little moisture in the air, but if the air is fully charged to saturation point, there will be no evaporation, and both dry and wet bulb readings will be the same.

Mathematical tables are available by which from readings of the two thermometers humidities can be calculated, i.e. the percentage ratio between the amount of moisture present and the amount required to saturate the air at the prevailing dry bulb temperature.

Absolute Humidity.

The adjective "absolute" is less commonly used to qualify the humidity. This is also calculated from the readings of the wet and dry bulbs, and refers to the mass or actual amount of water vapour present in each unit volume of air. It is expressed in either so many grains per cubic foot or so many grammes per cubic metre of air, but no such statistical references are made in the attached tables under the humidity columns.

The warmer the air is, the more water vapour it will absorb and hold, and, for this reason, it will be noticed that, on the average, the New Guinea humidity figures are much higher than in cooler climates. The temperature to which unsaturated air is reduced before it becomes saturated, is termed the dew point or the temperature at which moisture forms in visible drops. This is usually the lowest temperature of the night.

Dew readily collects on grass, metals or any good radiating surface and frequently appears on clear nights. Heavy dew is often a sign of good weather and the greater the difference between the wet and dry bulb thermometers, the greater are the chances of the weather being fine. It might be mentioned that the moisture which forms the dew is sometimes derived from the transpiration of plants, and thus in the mornings slight moisture may be seen condensed on the leaves of plants. Many New Guinea plants have particular adaptions for transpiration of moisture, while their flowers are so formed as to protect them from the effects of excessive moisture.

The average relative humidity is a most important factor in the growth of plant life and especially for such crops as sugar, tobacco, &c.

Observation of the behaviour of humidity is of importance to planters when drying their copra. For instance, where copra driers are situated near, or in, a valley the saturated cool night breeze drifting down the valleys makes drying extremely difficult.

Copra may have been thoroughly dried, but where the humidity is high, the copra will absorb a certain amount of moisture during the night and dry out during the heat of the day. In such situations, it is better to bag the copra later in the day when the atmosphere is usually drier than in the early morning when humidity is often greatest.

From observations taken over a period of years at five main coastal stations throughout the Territory, the average relative humidity is 81 per cent. at 9 a.m., 75 per cent. at 3 p.m. and 88 per cent. for 9 p.m. readings.

When the air movement is held in check by the dense virgin bush or jungle as in many parts of the Territory, the relative humidity is likely to be higher than the previously quoted humidity figures, and on the highlands and plain country, it would doubtless be lower on the average.

Other Local Climatic Influences.

Forests.

Forests exert a marked local effect on climate as the sun's rays cannot reach the ground through the dense foliage which attracts the cool and denser vapours.

Cumulus Clouds over Rabaul taken from Taliligap.

If the forests are cleared, the atmosphere in such recently exposed places becomes warmer and drier. This fact was pointed out in this *Gazette* (vol. 4, No. 1), when discussing rainfall and forests.(2) Of course a similar warming and drying effect is noticeable after the drainage of swampy land; should the soil be of a sandy nature, it will be noticeably hotter than in clay country.

Aspect.

A southern and eastern aspect is usually cooler and more moist than a situation with a northerly and western one—a feature with which architects and horticulturists are often concerned.

In hilly country the lie of the land will have a marked effect on the climate. In the narrow valleys the side having the most shade may be cool and moist, while the opposite side would probably be warm and dry, thus causing an appreciable difference in climatic conditions between places relatively nearby.(7)

Some plantations and parts of plantations, for instance, have been suspected of receiving too much rainfall and too little sunshine to be payable propositions.

Sheltered situations will have a different climate from places exposed to the wind and weather, but if desired this defect can usually be controlled by the use of wind-breaks, as explained in previous notes on rainfall, which appeared in Vol. 4, No. 1 of this *Gazette.*(2)

Changes in climate are presumed to occur in isolated instances. History shows for instance the change in the eastern portion of the Sahara where the orchards and cereal fields of Carthage at one time covered hundreds of square miles; now there is only desert.

The department is grateful to those stations that have regularly submitted rainfall figures which have enabled the compilation of the rainfall map appearing in this issue.

This office would welcome, in addition to rainfall statistics, such particulars as pressures, temperature, moisture, cloudiness, sunshine, wind direction and velocity and visibility. It is the state of these meteorological elements over a considerable period of time which is required to complete a picture of the climate of any particular place and region. In fact, without a statistical treatment of such collated information, the latest science of long-range forecasting will be impossible.

As illustration of usefulness of an isolated type of information, weather bureaux have co-opted the services of air liners to give weather conditions and especially temperatures encountered at various heights to assist in forecasting, and the spread of existing weather conditions. From both an agricultural and health point of view, actual climatic conditions have a great bearing on the incidence of disease, whether of humans, animals or plants. In short, the principal factor controlling all growth life is climate.

Apart from illuminating statistical facts such as compiled from the attached climatological tables, observers who care to follow this subject will obtain an aesthetic delight from a study of changing weather phenomena, and to cite Ruskin—

> It (meteorology) is a science of the pure air, and the bright heaven; its thoughts are amidst the loveliest of creation; it leads the mind, as well as the eye, to the morning mist, and the noon-day glory and the twilight cloud—to the purple peace of the mountain heaven—to the cloudy repose of the green valley; now expiating in the silence of the stormless aether—now on the rushing of the wings of the wind. It is indeed a knowledge, which must be felt to be, in its very essence, full of the soul of the beautiful.

REFERENCES.

(1) Ballot, Professor Buys, quoted by the *Meteorological Glossary*, Meteorological Office, London.

(2) Challis, B., Rainfall Notes, *New Guinea Agricultural Gazette*, vol. 4, No. 1, p. 39.

(3) *Australian Meteorological Observer's Hand-book*, 1925.

(4) Humboldt—Quoted by Nicholls and Holland—*A Text Book of Tropical Agriculture.*

(5) Lee, D. H. K., *Queensland Agricultural Journal—The Tropics and Man.*

(6) The *Meteorological Glossary*, Meteorological Office, London.

(7) *A Text Book of Tropical Agriculture*, by Nicholls, H. A., and Holland, J. H., Pub. Macmillan and Co., Ltd., London, 1929.

(8) *New Guinea Agricultural Gazette*, vol. 5, No. 1, p. 66 (Rabaul Climatological Data).

METEOROLOGICAL RECORDS.

STATION—AIYURA. DISTRICT—MADANG.

Subject—Temperature and Humidity.

(145° 55′ E., 6° 20′ S. 5,875 feet above sea-level.)

1938—Month.	Mean Temperature of.			Mean Humidity of—9 a.m. only.	1938.		1938.	
	Maximum.	Minimum.	Monthly.		Highest maximum.	Date.	Lowest minimum.	Date.
	°F.	°F.	°F.	%	°F.		°F.	
January ..	..	59.5	..	83	..	..	57.5	17th
February ..	..	59.5	..	83	..	..	58.6	22nd
March ..	..	59.0	..	83	..	..	56.6	16th
April ..	..	58.8	..	89	..	..	54.1	30th
May ..	..	56.9	..	89	..	..	53.6	25th
June ..	..	55.3	..	83	..	..	51.1	20th
July ..	..	55.0	..	88	..	..	52.8	25th
August ..	..	54.8	..	94	..	..	52.2	18th
September..	65.8	55.7	60.7	78	68.4	23rd	51.8	14th
October ..	66.1	56.9	61.5	94	67.9	24th	52.9	26th
November..	68.2	58.1	63.1	89	71.8	17th	54.9	5th
December ..	68.1	58.2	63.1	89	70.2	25th	54.5	12th
Average ..	..	57.3	..	87	..	..	..	..
Extremes ..	..	54.8 (Aug.)	..	94 (Aug. and (Oct.)	..	..	51.1	20/6/38

Mean Minimum Temperature for 1938=57.3 °F.

Mean Humidity (9 a.m.) for 1938=87%.

METEOROLOGICAL RECORDS.

STATION—AIYURA. DISTRICT—MADANG.

Subject—Rainfall.

(145° 55′ E., 6° 20′ S. 5,875 feet above sea-level.)

Month.	1938, monthly rainfall.	Monthly average rainfall since 1933.	1938.		Greatest monthly rainfall since 1933.	Year.	Least monthly rainfall since 1933.	Year.	1938, monthly wet-days.	Wet-days monthly average since 1933.	Amounts of clouds mean of 9 a.m. only.
			Greatest fall in 24 hours.	Date.							
	Inches.	Inches.	Inches.		Inches.		Inches.		Days.	Days.	
January	7.31	6.18	1.65	27th	7.98	1936	2.89	1934	22	21.3	5.1
February	9.65	7.40	2.28	10th	9.65	1938	3.24	1934	18	22.3	6.3
March ..	8.30	9.37	1.88	11th	11.36	1936	8.30	1938	16	20.7	4.9
April ..	7.46	7.19	1.26	5th	14.21	1935	4.38	1937	16	16.5	6.3
May ..	3.18	4.24	0.76	18th	7.73	1935	1.11	1936	17	16.2	6.3
June ..	2.31	6.44	0.44	10th	26.39	1934	0.77	1935	16	13.0	5.9
July ..	2.04	3.43	0.50	21st	4.83	1934	1.65	1936	13	16.5	4.9
August ..	1.45	3.98	0.23	6th	7.71	1933	1.45	1938	14	14.7	6.7
September	6.95	4.92	1.71	3rd	6.95	1938	2.98	1933	22	18.0	7.7
October..	10.45	5.92	2.30	15th	10.45	1938	2.96	1935	22	15.3	6.7
November	5.39	5.95	1.21	26th	12.53	1933	5.27	1936	18	15.7	6.0
December	7.84	7.60	1.03	12th	15.80	1934	3.64	1935	22	19.3	6.6
Average..	6.03	6.05	..	..	..	..	..	..	18	17.5	6.1
Extremes	10.45 (Oct.)	9.37 (Mar.)	2.30 (Oct.)	15th	26.39 (June)	1934	0.77 (June)	1935	22 (Jan., Sept., Oct., Dec.)	22.3 (Feb.)	7.7 (Sept.)

Rainfall for 1938=72.33 inches.
Average Annual Rainfall since 1933=72.62 inches.

METEOROLOGICAL RECORDS.

STATION—BULOLO. DISTRICT—MOROBE.

Subject—Temperature and Humidity.

(146° 39′ E., 7° 11′ S. 2,200 feet above sea-level.)

1938—Month.	Mean Temperature of.			Mean Humidity of— 9 a.m. only.	1938.		1938.	
	Maximum.	Minimum.	Monthly.		Highest maximum.	Date.	Lowest minimum.	Date.
	°F.	°F.	°F.	%	°F.		°F.	
January	89.7	68.8	79.2	81	95.2	20th	65.1	4th
February	88.5	68.8	78.6	86	92.0	2nd	62.9	28th
March	89.0	68.1	78.5	81	92.5	17th	63.0	28th
April	89.6	69.2	79.4	77	91.8	14th	65.0	8th
May	86.1	67.4	76.7	81	89.5	8th	61.4	27th
June	85.0	66.9	75.9	76	89.6	3rd	62.1	2nd
July	85.6	64.8	75.2	68	91.9	3rd	59.6	2nd
August	84.5	64.2	74.3	72	92.0	25th	57.9	17th
September	86.1	67.3	76.7	81	91.5	14th	61.8	15th
October	87.5	67.1	77.3	77	92.5	28th	61.9	24th
November	89.2	68.4	78.8	77	93.2	6th	60.8	18th
December	88.6	68.7	78.6	81	92.5	16th	62.5	21st
Average	87.5	67.5	77.4	78.2	..	..	..	..
Extremes	89.7 (Jan.)	64.2 (Aug.)	79.4 (Apr.)	86 (Feb.)	95.2	20/1/38	57.9	17/8/38

Mean Temperature for 1938=77.4 °F.
Mean Humidity (9 a.m.) for 1938=78.2%.

METEOROLOGICAL RECORDS.

STATION—BULOLO. DISTRICT—MOROBE.

Subject—Rainfall.

(146° 39′ E., 7° 11′ S. 2,200 feet above sea-level.

Month.	1938, monthly rainfall.	Monthly average rainfall since 1931.	1938.		Greatest monthly rainfall since 1931.	Year.	Least monthly rainfall since 1931.	Year.	1938, monthly wet-days.	Wet-days monthly average since 1931.	Amounts of clouds mean of 9 a.m. only.
			Greatest fall in 24 hours.	Date.							
	Inches.	Inches.	Inches.		Inches.		Inches.		Days.	Days.	
January	8.65	4.71	1.69	3rd	8.89	1931	1.40	1933	17	13.6	7.0
February	3.05	3.89	0.76	8th	6.15	1934	1.67	1931	10	11.5	7.0
March	6.29	6.36	1.52	8th	11.54	1931	3.16	1935	12	14.8	7.9
April	4.41	5.39	1.35	22nd	8.75	1933	3.15	1937	8	12.9	5.5
May	3.10	3.56	1.05	13th	7.92	1937	1.24	1933	12	12.2	6.0
June	3.28	2.38	0.70	9th	4.66	1932	0.85	1931	15	12.1	5.4
July	1.64	3.66	0.51	23rd	6.10	1937	1.64	1938	7	14.8	4.6
August	1.73	4.52	0.70	10th	8.91	1937	1.73	1938	7	14.9	5.6
September	4.46	4.56	1.18	24th	6.87	1936	1.97	1933	17	15.8	6.7
October	5.92	4.71	1.10	1st	8.64	1933	1.69	1932	14	13.8	5.7
November	6.11	6.29	2.48	24th	9.70	1933	4.35	1934	12	15.2	6.0
December	4.84	5.59	0.73	29th	10.84	1934	3.60	1936	16	14.7	6.2
Average	4.45	4.64	..	..	..	..	..	..	12.2	13.9	6.1
Extremes	8.65 (Jan.)	6.36 (Mar.)	2.48	24/11/38	11.54 (Mar.)	1931	0.85 (June)	1931	17 (Jan. and Sept.)	15.8 (Sept.)	7.9 (Mar.)

Rainfall for 1938=53.48 inches.
Average Annual Rainfall since 1931=55.62 inches.

METEOROLOGICAL RECORDS.

Station—Kavieng. District—New Ireland.

Subject—Temperature and Humidity.

(2° 34′ S., 150° 49′ E. North-west coast of New Ireland. 10 feet above sea-level.)

1938—Month.	Mean temperature of.			Mean humidity of.			1938.		1938.	
	Maximum.	Minimum.	Monthly.	9 a.m.	3 p.m.	Monthly.	Highest maximum.	Date.	Lowest minimum.	Date.
	°F.	°F.	°F.	%	%	%	°F.		°F.	
January ..	89.5	78.0	83.7	91	87	89	94.0	23rd	72.0	24th
February..	92.0	79.9	85.9	91	83	87	98.0	25th	72.1	16th
March ..	91.4	78.5	84.9	91	87	89	99.0	3rd	74.0	14th
April ..	90.8	78.7	84.7	91	91	91	97.0	20th	76.0	21st
May ..	91.2	78.5	84.8	95	91	93	94.0	14th	76.0	5th
June ..	89.1	77.9	83.5	91	87	89	92.0	15th	73.0	29th
July ..	90.4	79.6	85.0	91	91	91	92.2	18th	74.0	13th
August ..	92.3	81.0	86.6	87	88	87.5	98.0	31st	77.0	23rd
September	93.6	80.3	86.9	91	92	91.5	98.0	1st	75.0	21st
October ..	91.2	78.5	84.8	91	92	91.5	98.0	6th	70.0	30th
November	89.7	77.5	83.6	87	87	87	94.0	2nd	72.0	18th
December	88.0	77.2	82.6	87	87	87	92.0	22nd	72.0	31st
Average ..	90.8	78.8	84.8	90.3	88.7	89.5	..	..	..	..
Extremes	93.6 (Sept.)	77.2 (Dec.)	86.9 (Sept.)	95 (May)	92 (Sept. and Oct.)	93 (May)	99.0	3/3/38	70.0	30/10/38

Mean Temperature for 1938=84.8 °F.
Mean Humidity for 1938=89.5%.

METEOROLOGICAL RECORDS.

Station—Kavieng. District—New Ireland.

Subject—Rainfall.

(2° 34′ S., 150° 49′ E. North-west Coast of New Ireland. 10 feet above sea-level.)

Month.	1938, monthly rainfall.	Monthly average rainfall since 1917.	1938.		Greatest monthly rainfall since 1917.	Year.	Least monthly rainfall since 1917.	Year.	1938, monthly wet-days.	Wet-days monthly average since 1917.	Amounts of clouds mean of 9 a.m., 3 p.m., 9 p.m.
			Greatest fall in 24 hours.	Date.							
	Inches.	Inches.	Inches.		Inches.		Inches.		Days.	Days.	
January	24.20	12.02	3.40	28th	30.07	1923	2.78	1934–35	19	16.9	5.3
February	11.52	11.33	3.35	16th	20.37	1924	1.40	1917	20	16.6	3.7
March ..	10.07	11.48	2.65	18th	25.83	1920	4.53	1917	19	17.4	2.4
April ..	8.60	11.26	1.52	20th	26.46	1921	4.31	1924	14	16.2	2.4
May ..	4.31	10.19	1.62	31st	17.27	1931	4.31	1938	10	15.8	1.3
June ..	12.22	8.74	3.67	28th	19.80	1923	3.60	1924	15	15.5	3.6
July ..	6.21	9.25	2.59	1st	17.85	1929	3.61	1917	12	16.9	4.8
August ..	3.29	9.74	1.81	24th	24.57	1929	1.30	1924	10	16.5	3.6
September	2.00	7.32	0.97	10th	18.24	1934	1.63	1918	5	14.0	3.6
October..	5.96	8.95	2.33	8th	22.43	1928	0.87	1917	11	15.7	4.1
November	16.07	9.25	3.84	19th	19.24	1936	2.47	1917	18	15.5	5.5
December	15.02	10.67	2.30	30th	18.30	1929	3.68	1933	20	16.7	6.4
Average..	9.96	10.02	..	..	..	..	..	..	14.4	16.1	3.9
Extremes	24.20 (Jan.)	12.02 (Jan.)	3.84	19/11/38	30.07 (Jan.)	1923	0.87 (Oct.)	1917	20 (Feb. and Dec.)	17.4 (Mar.)	6.4 (Dec.)

Rainfall for 1938=119.47 inches.
Average Annual Rainfall since 1917=120.20 inches.

METEOROLOGICAL RECORDS.

STATION—KIETA. DISTRICT—KIETA.

Subject—Temperature and Humidity.

(6° 13′ S., 155° 39′ E. East Coast of Bougainville Island. 150 feet above sea-level.)

1938—Month.	Mean temperature of.			Mean humidity of.			1938.		1938.	
	Maximum.	Minimum.	Monthly.	9 a.m.	3 p.m.	Monthly.	Highest maximum.	Date.	Lowest minimum.	Date.
	°F.	°F.	°F.	%	%	%	°F.		°F.	
January ..	87.2	77.2	82.2	79	72	75.5	92.5	5th	75.5	23rd
February..	..	..	..	83	79	81.0	..	..	..	..
March ..	88.1	76.8	82.4	79	76	77.5	91.0	3rd	74.6	25th
April ..	88.4	75.9	82.1	76	79	77.5	90.9	11th	73.0	23rd
May ..	86.9	77.2	82.0	75	76	75.5	90.0	25th	73.0	2nd
June ..	86.2	76.3	81.2	83	75	79.0	90.8	11th	73.0	9th
July ..	86.4	75.4	80.9	78	69	73.5	89.0	4th	73.0	25th
August ..	87.0	79.2	83.1	79	72	75.5	89.0	27th	73.5	31st
September	86.7	76.0	81.3	79	76	77.5	91.0	5th	73.5	1st
October ..	86.9	77.1	82.0	79	76	77.5	90.5	21st	74.5	29th
November	86.0	76.3	81.1	75	76	75.5	90.0	3rd	75.0	28th
December	83.3	76.1	79.7	83	83	83.0	88.5	4th	74.0	4th
Average ..	86.7	76.7	81.6	79	75.8	77.4	..	..	..	..
Extremes	88.4 (April)	75.4 (July)	83.1 (Aug.)	83 (Feb, June and Dec.)	83 (Dec.)	83.0 (Dec.)	92.5	5/1/38	73.0	23/4/38 2/5/38 9/6/38 25/7/38

Mean Temperature for 1938=81.6 °F.
Mean Humidity for 1938=77.4%.

METEOROLOGICAL RECORDS.

STATION—KIETA. DISTRICT—KIETA.

Subject—Rainfall.

(6° 13′ S., 155° 39′ E. East Coast of Bougainville Island. 150 feet above sea-level.)

Month.	1938, monthly rainfall.	Monthly average rainfall since 1917.	1938.		Greatest monthly rainfall since 1917.	Year.	Least monthly rainfall since 1917.	Year.	1938 monthly wet-days.	Wet-days monthly average since 1917.	Amounts of clouds mean of 9 a.m., 3 p.m., 9 p.m.
			Greatest fall in 24 hours.	Date.							
	Inches.	Inches.	Inches.		Inches.		Inches.		Days.	Days.	
January	7.64	10.65	2.88	23rd	19.52	1927	4.79	1925	13	18.7	7.3
February	11.34	10.58	2.82	14th	36.02	1927	2.79	1937	12	18.0	9.2
March ..	15.23	11.04	5.08	25th	33.67	1917	3.88	1926	23	18.8	7.1
April ..	16.63	11.56	4.57	6th	22.43	1925	3.93	1936	16	17.4	5.3
May ..	3.65	8.77	0.62	21st	15.13	1923	2.02	1924	16	16.8	5.7
June ..	4.72	8.57	0.68	9th	19.11	1920	2.49	1924	16	16.9	5.4
July ..	4.70	10.48	0.54	*	22.31	1921	4.89	1924	15	17.7	4.5
August ..	4.36	9.63	0.55	15th	20.29	1925	1.94	1922	20	15.8	5.2
September	6.76	8.83	1.54	19th	17.66	1924	1.65	1935	15	15.9	5.1
October..	4.02	9.67	0.54	25th	27.01	1928	4.11	1932	12	16.4	5.0
November	7.51	9.26	2.73	28th	15.69	1936	2.60	1930	15	15.8	6.2
December	11.89	9.17	2.37	1st	18.70	1921	1.33	1925	22	17.2	6.7
Average..	8.20	9.85	..	..	..	..	..	..	16.3	17.1	6.0
Extremes	16.63 (Apr.)	11.56 (Apr.)	5.08	25/3/38	36.02 (Feb.)	1927	1.33 (Dec.)	1925	23 (Mar.)	18.8 (Mar.)	9.2 (Feb.)

Rainfall for 1938=98.45 inches.
Average Annual Rainfall since 1917=118.21 inches.

* = 2nd, 8th and 25th July, 1938.

METEOROLOGICAL RECORDS.

STATION—MADANG. DISTRICT—MADANG.

Subject—Temperature and Humidity.

(5° 11′ S., 145° 48′ E. 15 feet above sea-level.)

1938—Month.	Mean temperature of.			Mean humidity of.			1938.		1938.	
	Maximum.	Minimum.	Monthly.	9 a.m.	3 p.m.	Monthly.	Highest maximum.	Date.	Lowest minimum.	Date.
	°F.	°F.	°F.	%	%	%	°F.		°F.	
January ..	88.0	73.7	80.8	83	72	77.5	94.0	17th	70.0	14th
February..	87.0	74.9	80.9	95	79	87.0	92.0	3rd	70.0	16th
March ..	84.1	74.6	79.3	87	75	81.0	86.5	28th	69.5	19th
April ..	84.4	74.1	79.2	83	75	79.0	87.5	11th	71.7	17th
May ..	84.5	74.3	79.4	83	75	79.0	86.8	9th	71.5	24th
June ..	84.0	73.5	78.7	91	75	83.0	86.5	8th	68.9	11th
July ..	83.9	72.9	78.4	95	75	85.0	85.7	8th	69.3	10th
August ..	84.8	74.2	79.5	91	75	83.0	86.8	28th	72.5	4th
September	83.1	74.1	78.6	91	79	85.0	86.2	16th	71.3	30th
October ..	83.3	73.5	78.4	91	79	85.0	86.1	19th	71.3	2nd
November	84.4	74.4	79.4	91	79	85.0	86.6	16th	70.0	4th
December	83.9	74.3	79.1	91	83	87.0	88.9	6th	72.3	27th
Average ..	84.6	74.0	79.3	89	77	83.0	..	..	..	..
Extremes	88.0 (Jan.)	72.9 (July)	80.9 (Feb.)	95 (Feb. and July)	83 (Dec.)	87.0 (Feb. and Dec.)	94.0	17/1/38	68.9	11/6/38

Mean Temperature for 1938=79.3 °F.
Mean Humidity for 1938=83%.

METEOROLOGICAL RECORDS.

STATION—MADANG. DISTRICT—MADANG.

Subject—Rainfall.

(5° 11′ S., 145° 48′ E. 15 feet above sea-level.)

Month.	1938, monthly rainfall.	Monthly average rainfall since 1917.	1938.		Greatest monthly rainfall since 1917.	Year.	Least monthly rainfall since 1917.	Year.	1938, monthly wet-days.	Wet-days monthly average since 1917.	Amounts of clouds mean of 9 a.m., 3 p.m., 9 p.m.
			Greatest fall in 24 hours.	Date.							
	Inches.	Inches.	Inches.		Inches.		Inches.		Days.	Days.	
January	19.72	12.39	4.57	5th	21.27	1935	0.10	1925	25	19.7	7.7
February	6.30	11.57	1.73	14th	24.24	1919	4.82	1925	18	17.7	8.5
March ..	17.69	15.04	5.81	19th	27.92	1919	4.95	1925	18	20.9	5.3
April ..	23.26	16.96	6.25	17th	31.20	1921	4.79	1936	19	20.4	5.3
May ..	9.65	14.79	3.55	17th	25.23	1935	6.77	1934	20	19.2	4.7
June ..	8.20	9.96	3.88	9th	27.65	1923	2.74	1931	22	17.1	4.0
July ..	14.04	7.82	3.07	18th	15.77	1930	1.65	1919	21	14.1	5.0
August ..	5.71	4.79	2.49	21st	14.95	1936	0.03	1919	18	9.5	5.5
September	17.38	5.89	3.80	30th	17.38	1938	0.06	1930	19	14.0	5.3
October..	14.76	9.75	2.15	29th	20.74	1920	2.97	1930	24	13.3	6.3
November	13.80	18.27	3.97	26th	20.85	1936	6.42	1918	18	16.5	8.3
December	12.14	14.16	1.69	8th	31.80	1927	4.41	1918	24	19.6	8.3
Average	13.55	11.78	..	..	..	..	..	..	20.5	16.8	6.2
Extremes	23.26 (Apr.)	18.27 (Nov.)	6.25	17/4/38	31.80 (Dec.)	1927	0.03 (Aug.)	1919	25 (Jan.)	20.9 (Mar.)	8.5 (Feb.)

Rainfall for 1938=162.65 inches.
Average Annual Rainfall since 1917=141.39 inches.

METEOROLOGICAL RECORDS.

STATION—LORENGAU. DISTRICT—MANUS.

Subject—Temperature and Humidity.

(2° 2′ S., 147° 19′ E., North Coast Manus. 20 feet above sea-level.)

1938—Month.	Mean temperature of.			Mean humidity of.			1938.		1938.	
	Maximum.	Minimum.	Monthly.	9 a.m.	3 p.m.	Monthly.	Highest maximum.	Date.	Lowest minimum.	Date.
	°F.	°F.	°F.	%	%	%	°F.		°F.	
January ..	86.7	74.1	80.4	87	76	81.5	91.0	23rd	71.5	12th
February..	86.9	74.0	80.4	87	83	85.0	89.5	5th	71.5	3rd
March ..	89.0	73.3	81.1	87	76	81.5	92.5	17th	71.0	29th
April ..	88.6	74.6	81.6	87	76	81.5	94.5	30th	73.0	29th
May ..	90.5	75.2	82.8	83	69	76.0	92.0	31st	73.0	17th
June ..	88.1	76.4	82.2	86	72	79.0	92.0	1st	73.5	1st
July ..	88.0	73.2	80.6	91	69	80.0	93.0	6th	68.0	8th
August ..	90.0	72.7	81.3	95	80	87.5	93.0	28th	71.5	11th
September	88.6	73.2	80.9	91	88	89.5	92.0	1st	71.0	15th
October ..	89.4	73.2	81.3	91	92	91.5	94.0	21st	70.5	4th
November	88.4	73.6	81.0	83	83	83.0	93.0	9th	71.0	1st
December	86.5	73.2	79.8	91	91	91.0	90.5	25th	71.0	13th
Average ..	88.4	73.9	81.1	88.3	79.6	83.9	..	..	..	..
Extremes	90.5 (May)	72.7 (Aug.)	82.8 (May)	95 (Aug.)	92 (Oct.)	91.5 (Oct.)	94.5	30/4/38	68.0	8/7/38

Mean Temperature for 1938=81.1 °F.
Mean Humidity for 1938=83.9%.

METEOROLOGICAL RECORDS.

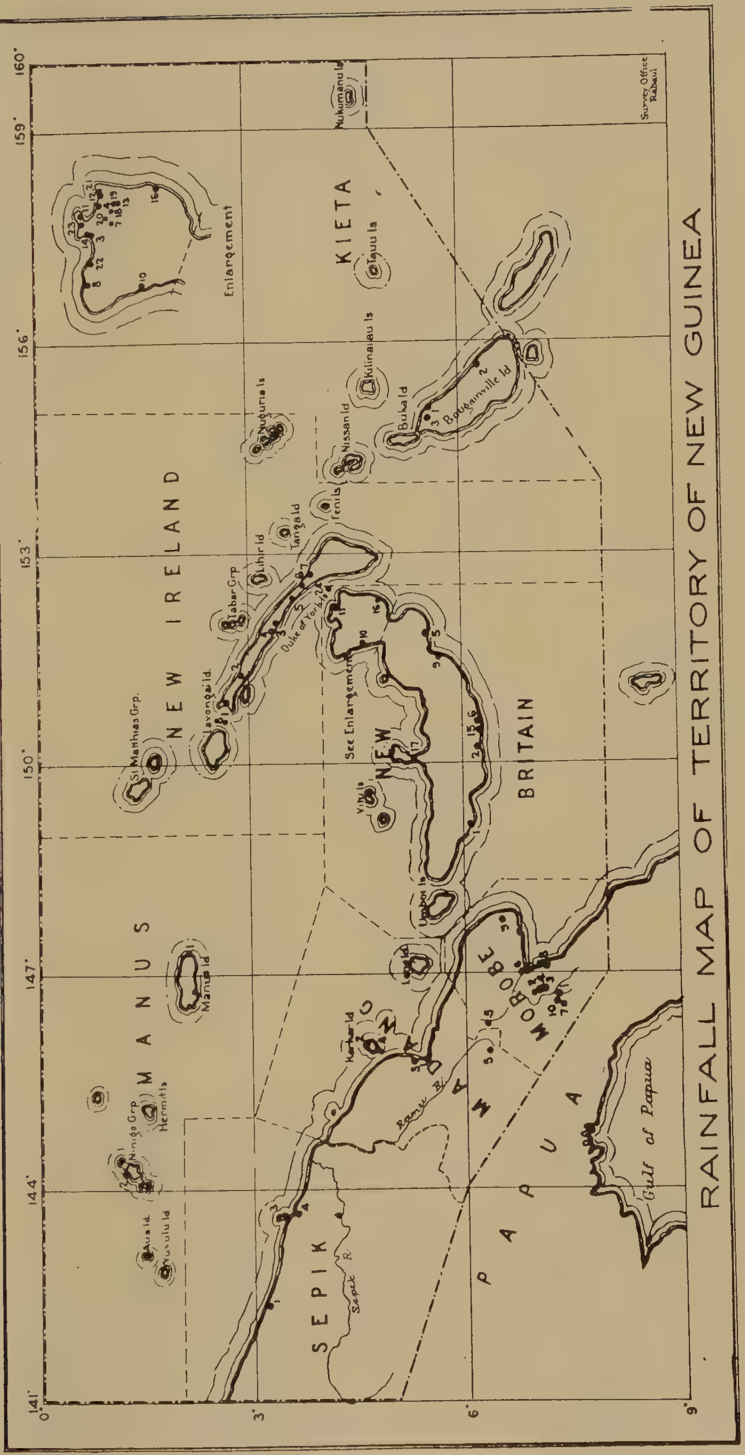
STATION—LORENGAU. DISTRICT—MANUS.

Subject—Rainfall.

(2° 2′ S., 147° 19′ E. North Coast Manus. 20 feet above sea-level.)

Month.	1938, monthly rainfall.	Monthly average rainfall since 1917.	1938.		Greatest monthly rainfall since 1917.	Year.	Least monthly rainfall since 1917.	Year.	1938, monthly wet-days.	Wet-days monthly average since 1917.	Amounts of clouds mean of 9 a.m., 3 p.m., 9 p.m.
			Greatest fall in 24 hours.	Date.							
	Inches.	Inches.	Inches.		Inches.		Inches.		Days.	Days.	
January	23.60	11.24	4.20	12th	23.60	1938	4.59	1925	21	18.4	7.8
February	7.53	11.36	3.56	17th	23.90	1933	0.24	1917	13	14.6	7.5
March ..	9.12	11.71	1.51	7th	17.25	1930	6.02	1926	16	18.7	6.7
April ..	12.68	14.17	3.20	7th	22.25	1919	3.45	1936	21	18.7	7.2
May ..	6.50	10.63	1.40	30th	15.01	1931	3.73	1924	12	18.4	5.5
June ..	10.50	13.27	2.91	9th	20.97	1932	5.03	1917	21	15.3	3.2
July ..	14.30	17.32	3.15	21st	33.46	1929	6.71	1933	19	20.1	2.5
August ..	7.61	16.30	1.72	18th	30.61	1937	1.51	1919	17	18.7	2.0
September	5.89	10.41	1.63	30th	19.09	1934	1.28	1919	17	16.6	3.1
October..	2.29	10.57	1.48	10th	21.56	1928	2.29	1938	7	16.8	2.6
November	11.58	11.15	2.42	18th	19.05	1936	2.93	1924	18	17.0	3.8
December	17.61	11.42	2.15	28th	26.56	1920	2.43	1925	22	18.1	4.9
Average..	10.77	12.46	..	..	..	..	..	..	17	17.6	4.7
Extremes	23.60 (Jan.)	17.32 (July)	4.20	12/1/38	33.46 (July)	1929	0.24 (Feb.)	1917	22 (Dec.)	20.1 (July)	7.8 (Jan.)

Rainfall for 1938=129.21 inches.
Average Annual Rainfall since 1917=149.55 inches.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RAINFALL MAP OF TERRITORY OF NEW GUINEA

TERRITORY OF NEW GUINEA.

Annual Rainfall and Monthly Average (in Inches).

District—New Britain.

Number.	Locality.	1938 rainfall.	Years recorded.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
1	Arawe ..	162.82	5	3.35	3.90	7.45	7.89	16.15	20.38	26.34	29.29	29.83	14.88	8.71	5.13	173.30
2	Gasmata ..	172.98	19	5.43	5.79	7.28	10.44	24.75	28.99	36.90	45.15	35.77	20.28	12.83	7.70	241.31
3	Keravat ..	76.25	9	11.92	9.69	10.57	10.58	9.47	5.94	6.61	5.70	7.33	9.11	9.63	8.94	105.49
4	Kokopo ..	56.55	12	9.96	6.99	10.39	7.01	5.19	3.97	5.98	6.72	3.33	4.94	6.43	9.97	80.88
5	Kolai ..	137.13	6	6.47	8.15	8.28	9.88	18.15	24.30	28.69	35.46	21.05	10.50	13.41	7.84	192.18
6	Lindenhafen ..	194.41	19	7.22	6.40	6.06	11.01	27.31	33.94	39.39	44.63	34.93	19.52	13.51	8.27	252.19
7	Malaboga ..	76.45	1	11.12	5.91	11.70	8.63	1.61	3.12	1.12	0.32	5.44	8.88	8.07	10.53	76.45
8	Notre Mal ..	159.85	10	32.34	18.60	20.98	12.26	8.19	7.63	7.11	7.88	6.39	6.66	9.31	16.59	153.94
9	Palmalmal ..	107.78	7	7.30	8.75	8.43	10.59	19.96	15.76	29.33	41.64	16.82	13.76	9.79	9.02	191.15
10	Pondo ..	141.81	12	36.60	24.82	19.27	15.02	8.13	7.82	9.36	9.39	8.21	6.69	8.83	19.17	173.31
11	Rabaul ..	72.52	25	14.32	10.59	9.53	9.66	5.07	3.42	5.55	4.33	3.67	5.21	6.41	10.32	88.08
12	Rapopo ..	61.92	6	9.86	7.48	9.66	6.94	4.87	4.43	4.19	7.25	3.35	5.88	5.90	7.36	77.17
13	Ralabang ..	77.65	1	4.30	8.26	7.96	18.40	1.80	5.26	2.35	3.12	1.60	6.86	3.98	13.76	77.65
14	Raulawat ..	81.05	5	15.78	6.04	11.89	6.00	6.62	6.08	6.81	7.52	7.86	9.57	8.01	7.39	99.57
15	Ring Ring ..	213.92	4	6.14	5.30	8.62	7.34	26.49	28.96	44.15	47.96	47.22	26.55	19.47	8.59	276.79
16	Sum Sum ..	97.16	6	8.86	10.54	9.13	7.01	11.89	8.37	17.17	20.89	11.79	11.14	10.16	11.19	138.14
17	Talasea ..	152.65	21	32.74	29.38	24.06	18.87	7.52	5.07	5.25	4.77	5.36	7.95	11.06	19.66	171.69
18	Tobera ..	84.43	8	9.73	8.09	10.36	9.59	3.99	3.14	6.00	5.97	3.22	4.82	8.53	8.06	81.50
19	Tovarur ..	50.09	1	5.95	8.18	4.94	7.46	0.17	3.34	2.50	1.68	1.00	1.75	4.44	8.68	50.09
20	Ulatawa ..	68.29	3	10.00	9.13	10.26	5.15	3.98	3.15	3.43	8.54	3.93	6.84	9.13	9.26	82.90
21	Ulaveo ..	60.71	1	8.28	6.21	4.52	11.82	1.93	7.84	3.73	0.48	0.61	3.12	4.18	7.99	60.71
22	Vunalama ..	73.22	1	12.77	4.27	6.85	14.22	0.33	4.74	1.19	3.62	2.64	4.48	9.14	8.97	73.22
23	Wangaramut ..	60.90	1	8.84	7.95	6.62	6.62	1.73	5.33	0.84	1.40	5.25	5.04	4.38	6.90	60.90
24	Watnabara ..	81.42	15	13.11	10.74	10.38	10.79	7.71	8.54	10.91	10.99	8.48	9.65	8.30	9.45	119.05

TERRITORY OF NEW GUINEA.

Annual Rainfall and Monthly Average (in Inches).

District and number.	Locality.	1938 rainfall.	Years recorded.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
New Ireland—																
1 ..	Kavieng ..	119.47	22	12.02	11.33	11.48	11.26	10.19	8.74	9.25	9.74	7.32	8.95	9.25	10.67	120.20
2 ..	Katu ..	121.91	3	23.13	13.25	21.57	9.11	5.78	5.22	6.39	11.15	8.71	9.17	13.17	14.24	140.89
3 ..	Kalili ..	123.17	15	22.63	13.73	16.25	10.60	10.49	11.91	19.16	16.98	15.29	16.15	13.84	20.80	187.83
4 ..	Kolube ..	151.73	1	23.41	28.06	18.42	12.71	4.32	11.91	5.98	5.40	0.86	1.79	14.79	24.08	151.73
5 ..	Komalu ..	72.58	1	2.40	11.65	13.51	5.59	4.20	8.80	5.74	1.57	1.08	2.65	5.05	10.34	72.58
6 ..	Matandeduk	116.63	3	21.71	12.60	17.87	5.55	3.68	2.96	2.43	9.21	4.06	4.86	12.94	17.23	115.10
7 ..	Namatanai	143.23	21	15.23	17.34	16.07	13.79	8.64	7.49	8.84	6.75	5.33	8.74	11.37	17.14	136.73
8 ..	Selapui ..	100.53	3	15.87	8.42	13.21	6.66	4.46	5.72	8.99	10.06	6.27	9.38	12.17	11.42	112.63
Kieta—																
1 ..	Hakau ..	100.57	3	9.53	17.09	14.10	8.93	7.52	5.21	8.12	6.44	6.90	7.18	10.65	6.14	107.81
2 ..	Kieta ..	98.45	22	10.65	10.58	11.04	11.56	8.77	8.57	10.48	9.63	8.83	9.67	9.26	9.17	118.21
3 ..	Raua ..	104.01	2	9.47	9.39	15.63	12.76	5.68	3.26	5.61	3.35	5.53	3.65	6.26	9.94	90.53
Manus—																
1 ..	Lorengau ..	129.21	21	11.24	11.36	11.71	14.17	10.63	13.27	17.32	16.30	10.41	10.57	11.15	11.42	149.55
2 ..	Pelleluhn ..	105.39	9	9.13	6.75	9.33	9.57	9.09	9.46	11.79	13.27	10.28	7.19	9.69	13.19	118.74
Morobe—																
1 ..	Edie Creek	89.85	9	8.16	7.50	12.05	11.06	6.94	4.63	6.04	6.46	8.67	8.74	11.17	13.31	104.73
2 ..	Baiune ..	70.72	5	5.46	6.24	8.46	4.60	4.27	2.54	4.50	4.45	5.93	5.48	9.80	6.74	68.47
3 ..	Bulolo ..	53.48	8	4.71	3.89	6.36	5.39	3.56	2.38	3.66	4.52	4.56	4.71	6.29	5.59	55.62
4 ..	Bulwa ..	71.93	4	7.09	5.89	6.90	5.18	4.84	1.81	3.79	3.86	5.43	5.27	8.09	5.29	63.44
5 ..	*Kaiyapit ..	93.87	10	9.51	8.61	13.60	12.14	5.22	2.03	2.64	2.59	3.36	5.98	7.95	11.52	85.15
6 ..	Lae ..	163.09	3	7.77	9.29	15.11	16.78	19.07	15.49	23.48	20.31	22.39	18.17	18.37	10.66	196.89
7 ..	Otibanda ..	66.68	3	3.54	5.97	4.38	4.91	6.16	3.12	4.65	3.51	5.55	7.31	7.05	3.70	59.85
8 ..	Salamaua ..	157.80	2	6.56	5.76	10.42	10.44	15.30	14.10	21.42	18.43	24.46	18.96	12.29	10.58	168.72
9 ..	†Sattleberg ..	188.76	13	4.98	5.93	6.82	8.63	20.05	17.92	25.78	28.68	26.22	12.95	11.85	6.74	176.55
10 ..	Wau ..	62.05	1	5.34	3.70	6.52	4.28	4.66	5.71	1.78	3.83	5.15	3.81	8.27	9.00	62.05
Madang—																
1 ..	Erimahafen	132.94	1	14.50	10.83	23.68	12.32	9.31	2.39	5.07	2.12	22.31	8.37	6.65	15.39	132.94
2 ..	Kulili ..	164.63	4	17.13	19.17	20.32	11.65	10.36	8.22	7.36	5.47	7.69	10.30	14.95	17.60	150.22
3 ..	Madang ..	162.65	21	12.39	11.57	15.04	16.96	14.79	9.96	7.82	4.79	5.89	9.75	18.27	14.16	141.39
4 ..	†Urit Kurum	134.41	13	11.08	10.77	12.13	10.48	11.88	7.83	6.65	6.82	6.23	11.25	9.65	10.30	115.07
5 ..	Ramu Aiyura	72.33	5	6.18	7.40	9.37	7.19	4.24	6.44	3.43	3.98	4.92	5.95	7.60	9.33	76.03
Sepik—																
1 ..	Aitape ..	90.86	18	10.01	10.56	10.53	9.52	7.86	6.35	6.98	6.64	5.01	6.33	7.99	10.21	97.99
2 ..	Angoram ..	73.22	4	10.40	10.07	10.14	9.52	6.22	7.43	3.00	3.94	3.84	7.10	6.45	11.06	89.17
3 ..	Kairiru ..	142.28	1	15.40	9.24	9.20	6.12	14.00	9.85	8.37	10.17	17.79	18.14	10.10	13.90	142.28
4 ..	Wewak ..	87.86	10	5.71	3.49	5.66	8.02	7.91	8.14	9.84	5.78	9.72	9.16	6.93	6.97	87.33

* = Figures for 1937. † = Figures for 1936. 1938 figures missing.

THE TIMBER INDUSTRY IN THE TERRITORY OF NEW GUINEA.

(*By J. L. d'Espeissis, B.Sc., B.Sc.For., Dip.For.*)

The timber industry in the Territory is as yet only in the developmental stages. The *Timber Ordinance* 1922-1931 was repealed and a new ordinance, known as the *Forestry Ordinance* 1936-1937, came into force on the 15th September, 1937. Two forestry officers were appointed early in 1938, in order to assist in the administration of the new Ordinance.

The timber industry has had a rapid growth. Two or three years ago it was practically nil. Prior to the year 1933, there is no mention of timber in the listed exports; in the year 1933-34 timber in the log form was exported to the value of £180; in 1934-35, to the value of £705; in 1935-36, to the value of £360. For the year 1937-38, this figure jumped to £6,030 for logs, and £480 for sawn timber. The timber in logs, for this year, measured 3,103,996 super. feet. This was all exported to Australia—a little eventually finding its way onto overseas markets. Approximately 1,300,000 super. feet of sawn timber were produced in the Territory during the same period—this, however, was absorbed by the local market. At the end of 1938, there were some nine mills in operation, while approximately 23,500 hectares of Administration land was held under forest permits to cut and remove timber; while, in addition, a considerable amount of cutting was taking place on private property.

Due to a high tariff against sawn timber entering Australia, timber has been exported from this Territory mainly in the log form. Log export operations are confined, at present, to the island of New Britain, where, in addition, some five saw-mills are located, supplying the local market and an occasional small shipment of sawn timber for overseas. Apart from a few small mission saw-mills in various parts of the Territory, the only other timber operations of any importance are confined to the vicinity of Kavieng and Wau. These centres, however, supply only to local markets.

In the vicinity of Wau, several small saw-mills cutting in the best-known stand of hoop pine, klinkii pine and cedar in the Territory, supply—due to the obvious restrictions imposed by air transport—only the gold-mining industry centred about Wau. It is hoped, however, following the construction of a road to the coast, to start an export trade in these timbers, to be run in conjunction with a planting programme on a scale sufficiently large to ensure a sustained yield.

The industry has experienced numerous setbacks in the past, due to several causes, the most obvious of which was due to the shipment to Australia of logs of poor quality—no selection or discrimination having been exercised in this matter. The species exported were unknown in Australia, and often even untried in the Territory. Timber of types not then known to the "trade" were upon occasions dumped in Australia, and, due to lack of selection and care in handling, many of these logs were pipy, of bad shape and often riddled with borers. This did incalculable harm to the reputation of some of the best New Guinea species.

It is realized, I think, by the chief exporters that care must be taken to correct these mistakes. The value of creosote as a useful preventative against borer infection is beginning to be appreciated. The creosoting of all logs exported from the Territory is now compulsory, unless special exemption has been obtained. Furthermore, facilities for export inspection by qualified officers are provided by the Administration for those who desire to avail themselves of this service. The importance of this inspection by an independent third party, between seller and buyer, cannot be stressed too strongly; for it will be necessary to live down the past by maintaining a high standard for the future. The regaining of this lost ground will be slow. It will be particularly important to study the requirements of the Australian and overseas markets, and regulate export to conform to demand, and not vice versa.

Australia's average annual softwood requirements amount to approximately 500,000,000 super. feet. Of this total she herself has supplied, during the last twelve years or so, an average of, approximately, 90,000,000 super. feet, which came almost entirely from Queensland, where it is now realized that the supply cannot last at this rate for many more years. It is apparent that an extra 90,000,000 super. feet will soon have to be procured from elsewhere. Promoters of this Queensland industry are eager to obtain hoop pine, or hoop pine substitutes, so they are naturally turning their eyes to New Guinea's hoop and klinkii pine resources as a means of supplying timber to enable them to carry on their established businesses. As already pointed out, the New Guinea pine stands are situated in the inaccessible highland regions of the mainland, where they will remain inaccessible until the construction of a road to the coast opens up this area.

Meanwhile, Erima (*Octomeles sumatrana*), a light-weight, light-coloured timber, from the readily accessible coastal forests, is proving to be a fairly general utility plywood proposition. Several other light-coloured, light-weight timbers from the coastal regions should also command a ready market, but they appear to be very susceptible to blue mould attack, which will debar them from export, until such time as a satisfactory technique for the prevention of blue stain in logs has been evolved, or tariff reductions allow the export of sawn timber on a profitable basis, when preventative measures could be taken here, immediately after sawing, to ensure that these timbers maintain their colour. Under such conditions, a new era should open up in the utilization of the coastal white scrub-woods.

Regarding hardwoods of the Territory, suitable for structural purposes, prospects are not so bright. It is most unlikely that an export trade to Australia will develop in these types; for Australia is the home of some of the world's best hardwoods. Apart from this the Territory's better hardwoods, i.e., kamarere (*Eucalyptus deglupta*) and kwila (*Afzelia bijuga*), do not occur in sufficiently large stands to warrant export. If the existing stands are not conserved for local use (for there is a definite need for durable hardwoods), it will be found in a few years that we will have to import all our building timbers from Australia—a quantity being already drawn from that source.

European markets have not been thoroughly explored, but there are indications that it may be possible to market in the United Kingdom a certain quantity of Taun (*Pometia pinnata*) as hardwood flooring. However, for medium-class hardwood timbers, such as this—of which there is no lack—the Far Eastern and South African markets are worthy of investigation. Considerable quantities of second-class Australian hardwoods are shipped to the Far East each year;

therefore, New Guinea—half way there—should be in an excellent position to supply this market. For those of our harder timbers possessing sufficient figure for cabinet work, there is hope that they may find favour in this guise in Australia and overseas.

Amongst those timbers suitable for cabinet work, there is one outstanding species, namely, laup, or New Guinea walnut (*Dracontomelum mangiferum*). The prospects regarding this species are particularly good. Once again, owing to the failing supplies of a Queensland timber—in this case, walnut—the "trade" now requires a new source of supply of this species, or else a satisfactory substitute, in order to meet the demand created by the popular Queensland walnut. This Territory is fortunate in having an excellent substitute for Queensland walnut in laup (*Dracontomelum mangiferum*). When carefully selected, it is a very handsome cabinet wood, of almost equal value as Queensland walnut. It is creating a considerable amount of interest in Australia and also in the United Kingdom and the United States of America. The market for this timber is already made; all that need now be done is to take sufficient care to maintain a satisfactory export standard in order to maintain it.

Other cabinet woods exist, but they will have to win popularity for themselves before they can become established on the markets of the world. This process will be slow and it can best be done by those firms in close touch with markets and having their own marketing organizations in Australia and overseas.

In view of this state of affairs, it is obvious, unfortunately, that selective logging—for the near future at least—is going to be a feature of the timber industry in this country, where, as is the case with most tropical rain forests, the mixture of species is a marked feature. This means that extraction costs will be relatively high. Also, due to the scattered and limited nature of felling operations, it will make the regeneration of economic species in exploited forests a difficult matter for the newly-created Forest Service. This, however, is only one of the many problems which have to be tackled and overcome. The future appears to hold considerable promise for the New Guinea timber trade; however, it does not do to be over-optimistic. It is necessary to face the fact that many difficulties will have to be overcome, and that it may be necessary to make haste slowly. However, with full co-operation between private enterprise and the Administration, these difficulties should prove to be by no means insuperable, and it should be possible to build up on a sound basis an industry which promises to rank timber with gold and copra, as being one of the Territory's foremost products.

SOME INVESTIGATIONS ON COCO-NUT DISEASES, ASSOCIATED WITH SOIL CONDITIONS IN NEW GUINEA.

(*R. E. P. Dwyer, B.Sc.Agr., Economic Botanist.*)

PART I.

Introduction.

In a article on the "Diseases of Coco-nuts (*Cocos nucifera*) in New Guinea" (see *New Guinea Agricultural Gazette,* Vol. 3, No. 1, April, 1937), (9), an account of the diseases due to fungi and physiological causes, so far recorded in this Territory, was presented. It was shown that chlorotic deficiency diseases of coco-nut palms which are associated with soil deficiency or soil exhaustion are very important in this country. Affected palms assume a sickly, yellowish-green colour, and the fronds gradually become shorter and fewer until eventually the few remaining fronds present a feathery, unhealthy appearance. The occurrences of this nature were fully described in the article quoted and are easily recognizable as due to soil deficiency. In the final stages tapering stem and general collapse of the bud or cabbage often results, primarily due to soil exhaustion. It is not proposed to deal with incidences of this type in the following discussion.

In the same issue several diseases which may be associated with unfavorable soil conditions and soil deficiency as main factors, together with other contributory causes, such as fungus attack, were described. These may be briefly listed as follows:—Chlorosis, tapering stem, die-back, bud-rot of certain kinds, nut-fall (some kinds), leaf-droop, leaf-break, tip-wither, frond-choke, drought wilt, production of leathery copra, and, finally, an "obscure physiological disease" found in New Ireland.

In describing the latter occurrence at some length (*see* pages 55 to 57 of the volume mentioned), it was stated in the general description that "one main distinguishing characteristic was the "wilting" of the central fronds of young palms in the affected areas".

It is the intention of this present article to publish some more detailed investigations on this "wilting" and "die-back" condition, and, also, to compare it with similar occurrences in other parts of the world. It should be mentioned that the owner of the plantation where this was most in evidence, and other planters in the vicinity, evinced considerable alarm over this disease. They believed, at first, that this condition was new to this Territory and was likely to spread on to adjoining properties, owing to the rapid appearance of the condition and the number of palms affected within a comparatively short time. For this reason, attention was paid to the attempts to solve the underlying causes of this "die-back" disease. The disease was investigated locally, both in the field and in the laboratory, during three separate seasons.

In an article on "The Fall of Mature Palms in New Guinea Plantations" (10), it was made clear that, from a practical stand-point, the study of soil profiles yields much information concerning the suitability of particular areas to coco-nut cultivation, even where chemical data is not available. It was also shown that coco-nuts can flourish and produce normally with a very restricted root system, providing the surface soil is physically and chemically rich. Where the soils are poor and compacted, root restriction and water-logging will finally lead to deficiency symptoms and soil exhaustion becoming apparent.

In addition to the particular occurrence at Namatanai, some other derangements of the coco-nut palm, associated with unfavorable soil, sub-soil and water table conditions, together with inter-related climatic and nutritional factors, are described. In Part 1 of this article some derangements of young palms at Kokopo, New Britain, and from Bougainville Island also are described.

Description of the "Maturation Wilt" of Young Coco-nut Palms in New Ireland.

The palms on the plantation where this condition was recorded ranged from five to eight years old, and, in most instances, had just commenced to come into bearing. The general condition of the palms, in the areas affected, did not appear so good as in the surrounding areas. The trouble was found only in areas well away from the beach where the palms were planted at the wide spacings of 33 feet and 36 feet on the triangle system. The main area which was affected was situated in a hollow depression and comprised a total of about 600 palms, and numerous palms scattered over this area showed symptoms as described. There were a couple of other widely-separated areas which showed the condition. The plantation has a great proportion of its planted area on slopes exposed to the strong north-west winds. This would aid in the additional loss of water by transpiration (i.e., given off through the leaves), as the north-west season is the dry season on that coast.

Pronounced tip-withering occurred on the centre leaves of the affected palms, and some dying back was also seen on the outer leaves. On the back of the petioles (leaf stalks) of the crown leaves of the palms, pale brown streaks were seen. These sometimes showed up near the tip of the leaf or near the base, but, as a general rule, commenced about two-thirds of the way up from the base. The scattered lesions, although moist in appearance, were quite firm, but later they tended to spread and link up, becoming sunken below the general level of the outer surface of the midrib. Eventually the diseased portions split longitudinally, exposing the fibres after the ground tissues had fallen away, and the unhealthy parts become quite dry and hard.

A cross-section made after drying out had occurred showed a pale, sulphury-yellow layer immediately underneath the sunken tissue; this merged into a brown discolouration extending through the petiole almost to the inner surface. In longitudinal section the discoloured portion showed up as full- reddish-brown streaks. Such rotted portions were seen in some cases to extend below the fibrous tissue at the base of the leaves, but in no case did it appear to kill the palms. A tip-wither of the leaflets which extended from the top of the fronds almost to the base generally occurred concurrently with the stem-rotting mentioned.

Around the edges of the withered sections on the leaflets a distinct halo was noticed in some cases and the "die-back" from the tips was very distinctive. Pale areas with brown margins also appeared in the centre of the leaflets. The above symptoms only showed up on the fronds comprising the crown, while the older leaves were usually not affected.

It appeared that the palms affected were tall, very erect and close-growing, and not an open, robust type. They often presented a frond-choked appearance with the fibrous tissue bound tightly round the bases of the fronds. The only palms affected were those bearing nuts, or flowering before coming into bearing. The nuts from diseased palms showed an unhealthy, yellow colour. Examination of the roots showed no evidence of root disease.

The land prior to planting was under fairly heavy secondary growth and in the past had been used as native gardens. The land is undulating and rises gently from the beach. The soil on the beach and ridges is shallow and overlies coraline limestone. On the slopes and in the depressions the soil was much deeper and, in places, reached a depth of about 4 feet. In the profile the soil on the slopes showed a medium, dark-red, friable loam at the surface, which rapidly merged into a red, or chocolate, rather stiff, clayey sub-soil. A heavy growth of weeds and shrubs was allowed to grow over the area and amongst these Thurston grass, *Paspalum conjugatum,* and Kunai, *Imperata arundinacea,* were seen on the affected areas.

The fungus, *Pestalozzia palmarum,* or grey blight, and the insect, *Brontispa Froggatti,* were scattered widely in the plantation. The diseased palms seemed to be more plentiful where a heavy infestation of white fly, *Aleurodicus destructor,* and other unidentified scales were present. These were more plentiful in the hollows than on the ridges. Microscopical examination of diseased specimens failed to show any strongly parasitic organisms, although it did yield some interesting results.

Detailed investigations by Henderson and the author led to the belief that the condition was local and of physiological origin, so that it appeared likely that the natural soil conditions were at fault. One interesting feature concerning the topography was the presence of several large holes or depressions such as are often seen in country of coral origin. These extended well down into the underlying coral, and in one case a stream of water was running at the bottom of the declivity. It is believed that there is a subterranean passage and a large underground water channel underneath the area where the palms were affected. Here the rain water readily penetrated to the lower layers and was quickly carried away.

It appeared, also, that the roots of the palms showing the upright frond-choked condition had only penetrated the upper and more friable layers of soil while the roots of the stronger palms had penetrated deeper into the sub-soil (*see* diagrams, Figures 1 and 2). Practically all of the affected palms when pushed strongly could be rocked backwards and forwards, showing that the rooting was shallow and that this type of palm had a loose hold on the soil. The root-hold had been further reduced by the doubtful expedient of digging in deeply around the palms, so that many of the surface roots were cut. Whether this was also affected by original shallow planting in the first instance was not known, but appears likely. The appearance of the disease was associated with a pronounced spell of dry weather following on relatively heavy rains. It occurred, however, where the soil was apparently well suited to coco-nuts, although a little heavy in the sub-soil. The rainfall for the months of April, May, June and July, 1936, i.e., preceding the appearance of the disease, was just about half the average for those months at the nearest recording station, but the rainfall was said to be much lower than this at the plantation in question.

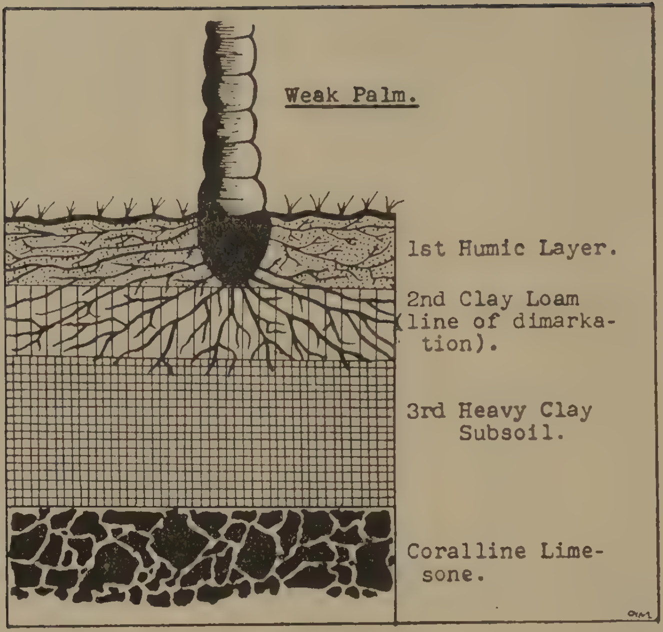
Weak Palm.
1st Humic Layer.
2nd Clay Loam (line of dimarkation).
3rd Heavy Clay Subsoil.
Coralline Limesone.
CHM

Figure 1.

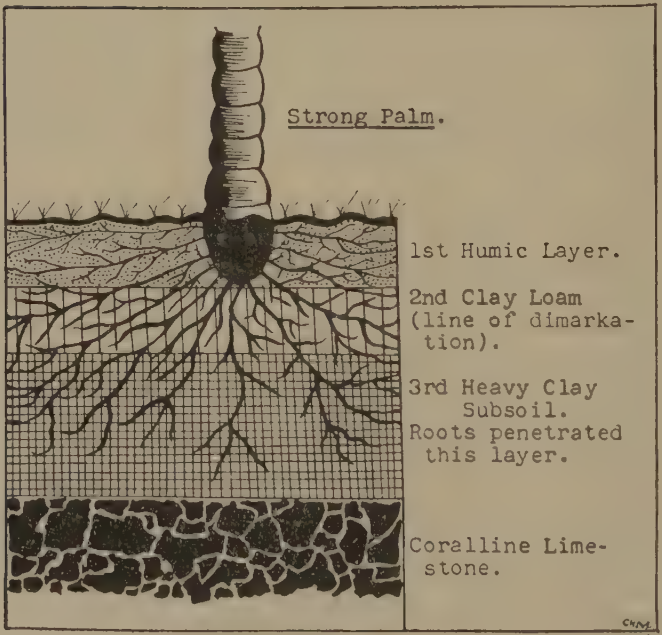
Strong Palm.
1st Humic Layer.
2nd Clay Loam (line of dimarkation).
3rd Heavy Clay Subsoil.
Roots penetrated this layer.
Coralline Limestone.
CHM

Figure 2.

The malady made an appearance when the palms were coming into bearing, which is a critical period in the life of the palm, when an additional strain is caused by increased water and nutritional requirements. This represents the change-over period from vegetative to productive phase.

During the dry period, shallow-rooting, rather weak palms were not able to obtain sufficient water and plant food to carry on normally, especially where the water could get away so easily. Further, insect attack and probably the effect of weakly-parasitic fungi had some effect when the vitality of these palms was lowered, and this caused some of the withering seen on the central leaves. Thus, there appeared to be a definite relationship between the incidence and severity of the disease and the type of palm.

It is a significant fact that recovery was coincident with the proper cleaning up of the place by cutting down high brush weeds, &c., and more particularly with the incidence of abundant rainfall. The white flies and various scale insects were very much less in evidence after the plantation was cleaned up and the rain occurred, which probably had some effect on the recovery of the palms.

The owner of this plantation became very concerned and drastically cut back many palms, in some cases, leaving only the central shoot, which led to the bud-rotting condition present, as this was probably associated with the entrance of secondary fungi and bacteria. Where the palms were cut back judiciously at a later interval and not too many fronds removed they made a good recovery.

Henderson observed that the streaking on the dorsal surface of the petioles (leaf stalks) was intimately connected with rotting tissues at the growing point. In the most seriously affected palms, a bud-rot was said to develop. It is not certain, however, how much of the sporadic bud-rotting which did occur was hastened by the drastic cutting back of the fronds of the affected palms, leading to the entrance and development of secondary organisms. It is most probable that, in some instances, bud-rotting did occur as a direct effect of physiological break-down, aided by secondary fungus and bacterial infection. The appearance of the diseased areas on the leaf stalks suggested physiological collapse of the cells due to faulty nutrition and failure of water supply, if, as it seemed, the fungi or bacteria isolated were not responsible for the longitudinal lesions seen. There were some minute boring larvae (apparently of a small moth or butterfly, but as they did not breed out they were unidentified) confined to some of the dead portions of the diseased streaks, where they were found in small, elongated tunnels, with their frass. Where any tendency of the bud to decay occurred, it was seen that it progressed typically from the leaf stalks inwards, which is apparently the reverse sequence to that found with the majority of bud-rot cases due to the *Phytopthora* fungus.

Where the ground was hoed over, in the dry season, all ground covers were removed, and the surface fibrous roots cut, which further exaggerated the drying out of the surface soil. Many feeding roots were destroyed on the young palms, with an already restricted root system, and this again diminished the water and nutrient supply to palms already suffering from deficiency. Such attempts at controlling the maturation wilt could only increase its effects, as was experienced.

The plantation on which the affection occurred was gradually planted over several years and the palms came into bearing roughly in the same order as the plantings were made.

Records show that the disease has appeared in the affected areas at approximately the same times in the corresponding seasons and in palms of similar age grouping in each of three years to 1937. At stated previously, none of the palms involved was more than eight years old.

The last visit to the plantation in connexion with this investigation was in August, 1937 (after the first description had been published). Then the disease again appeared in a patch of coco-nuts some distance away from the original focus, where the affected palms were also reaching the bearing stage in the dry season.

The owner had, ill-advisedly, cut the fronds so much that it was not possible to get suitable specimens of fronds showing streaking on the petioles for further examination.

Though the condition appeared at roughly the same period of the year, for successive years, as indicated above, it did not reappear later and no trouble was experienced during the year 1938 and up to June, 1939. It will be most interesting to see whether, in future years, it will appear in this plantation, under similar circumstances, in palms coming to the bearing stage. Though there is no sign of the disease at present, there is no guarantee that it will not occur again. The indications are very strong that palms which have passed the critical bearing stage on this property, and have recovered, or escaped the affection, are not liable to show a similar wilt again. The age factor must have an important interaction with other limiting factors present (such as water relationships, the type of soil, sub-soil and climate). As already pointed out, the plantings were made progressively, as time permitted, and in each year the disease occurred it was found in new areas.

Frond Choke.

The affected palms, in most instances, showed the condition of frond choke, which was also described in the article previously mentioned.(9)

In this case the terminal fronds tend to stand very erect and develop poorly. The outside leaves appear closely crowded around the growing point and their bases are held, or bound, together instead of growing free. The following fronds gradually become smaller and smaller as fresh ones appear, while the palm develops a sickly, yellow appearance and appears to lack vigour. As far as can be determined, there are no fungous pests responsible for this disease. It has been suggested that it is aggravated by close planting, unfavorable soil conditions, &c. Again there is a possibility that this is a virus disease, but as the condition is confined to definitely defined areas in many instances, this suggests some physiological derangement.

It appears that certain types of palms, which are very erect growers, are more liable to "frond choke" than others. Where this condition is present, it is wise to improve the cultural conditions, and, also, loosen the overhanging fibrous tissues at the bases of the constricted fronds.

The palms naturally tend to grow very upright where they are closely planted, and there is a dense canopy of closely intergrown fronds. This type of growth is also a common feature of replanted palms, growing under much older and taller palms, and it is an indication of light and, possibly, root competition. These latter occurrences of palms showing upright growing fronds are similar in effect, but not due, to the same causes as where "frond choke" is met in areas of poorly vigorous palms of approximately the same age and development.

Presence of Necrotic Deficiency Spotting.

It was seen when visiting the plantation that the palm fronds in the whole affected area showed a yellowish or bronzed appearance. On closer examination, it was found that the coco-nut fronds in these areas were suffering from what appeared to be a "deficiency spotting" all over the leaflets (leaf pinnules) at the time the physiological wilt occurred.

The coco-nut leaves showed countless small brown or yellowish-brown spots. These abundant spots were close together and were usually rounded and surprisingly regular in outline. Their appearance suggested some form of "necrosis", as no organisms were found associated with the numerous small brownish spots present. Where *Pestalozzia* was found, the spots were large, more irregular and coalesced, thus presenting an altogether different appearance.

Some fronds showing deficiency spotting and derived from the affected area, at Namatanai, were collected and sent to England for examination and comment.

The report(1) by Professor Ashby (February, 1938) on the spotted coco-nut leaflets sent to him was as follows:—

> The small spots appeared to be free from a fruiting fungus, but the large spots bore numerous pustules of ***Pestalozzia*** (or ***Pestalotia***) *palmarum*, Cke., a fungus of very wide distribution on coco-nuts. Its parasitism on healthy leaves has not been proved; it is probably only able to infect leaves which are in ill health, due to some other cause. The very abundant, small spots are suggestive of the "Cadang Cadang" disease in the Philippines, mentioned in my previous letter.
>
> At the present time, when a disease is thought to be of a physiological nature, one tends to think either of a virus or a soil deficiency, especially in some minor element (e.g., boron, manganese and zinc), especially if soil and subsoil conditions appear to be satisfactory in other respects, and there has been no very abnormal preceding weather.
>
> We are still much in the dark about the change in the nutrient requirements of the coco-nut as it comes into bearing. It is likely to be one of the investigations in progress at the Coco-nut Research Station, Ceylon. A chemical analysis of the soil would bring out any deficiency in the available amount of one or other of the major essential elements (potash, phosphoric acid and lime). Volcanic soils, in particular, are liable to be deficient in availability of one or other of those elements for some crop-plants. In the annual report for 1936 of the East Malling Research Station, there are a number of interesting papers by Roach (23-24) and others, on injecting fruit trees, including leaves, with mineral substances for the detection of deficiencies. These methods might give interesting data if tried on the coco-nut.

It might be explained here that steps had already been taken to have the soils analysed as suggested in this report. The author had previously conducted injection experiments with coco-nuts on a plantation near Kokopo with twelve different substances and some interesting results were obtained with several of the substances used.

These preliminary tests on soil-deficiency problems are largely the sphere of a soil chemist, and only where they have any bearing on the nature of the disease in New Ireland are they discussed here.

To illustrate the possible effects of rare metal deficiency, such as boron, the symptoms described by Denniss, in *Science Progress*, 1937,(7) are given—

> The most reliable diagnostic symptoms of boron deficiency in higher plants is *death* of the apical point of the stem. This is generally followed by stimulation in the growth of lateral buds, resulting in the formation of side shoots, which in turn die back at the

> tip. Leaves of affected plants are commonly slightly thickened, often tend to curl and may become slightly chlorotic. Frequently, the petioles (leaf stalks) are noticeably brittle, and, in many cases, the plants fail to bloom or to set fruit.

He goes on to describe the histological symptoms, which include lack of full normal development, especially in the roots. Although the effects of boron have not yet been observed in coco-nuts, this description gives a good idea of what is not unlikely to happen here where rare metal deficiencies occur. Experiments already carried out have shown that iron compounds and such elements as copper sulphate, $CuSO_4$ (bluestone), in weak solution, do have a stimulating effect on chlorotic palms in this country.

It might be pointed out that sulphate of iron (ferrous sulphate, $FeSO_4$, $7H_2O$) has been used rather widely as a manure by one company on several plantations in the pumice belt near Rabaul, with good effect on the appearance and vigour of the palms. It does change the chlorotic appearance of the palms and causes their fronds to assume a more normal, healthy, green colour. It has been claimed that this quick effect is because the iron-sulphate assists in liberating certain plant foods in the soil(3) (i.e., purely due to catalysis). Its direct effect has, however, been indicated where the author carried out injection experiments with dilute solutions of the iron sulphate. The effect of iron was further confirmed where solid ferric citrate, $C_6H_5O_7$ (Fe_3) was injected into the chlorotic palms and gradually restored their colour. The direct tonic effect of ferric and other iron compounds on fruit trees and other plants, when applied in proper strength solutions, has also been amply demonstrated in other countries. When applied to the soil, it is almost certain that liberation of plant foods as well as the direct effect would occur.

Cadang Cadang Disease.

The Director of the Imperial Mycological Institute wrote as follows, which led us to make inquiries along the lines suggested:—

> In the *Philippines Agriculturist*, vol. 26, No. 4, September, 1937, there is a short article by G. O. Ocfemia,(19) entitled "The Probable Nature of Cadang Cadang Disease of the Coco-nut." The symptoms described are suggestive of the "physiological disease" in New Ireland. Ocfemia, who has done some valuable work on virus diseases [bunchy top of Abaca (*Musa textilis*) and Fiji disease of sugar-cane], believes that the symptoms of the Cadang Cadang disease point to a virus causation.

Ocfemia, in reply to a letter from the present writer, stated that no further work had been carried out to determine the causal nature of the disease in question.

A condensed review of Ocfemia's article(19) is given from the *Review of Applied Mycology,* p. 108, February, 1938—

> Coco-nuts on San Miguel Island (Philippines) were observed, in 1931, to be affected by a disease known locally as "Cadang Cadang" or growth failure and involving 25 per centum of the palms in some parts of the affected estate. The leaves were yellow and chlorotic, developing numerous yellowish, translucent spots, which turned orange-yellow. From a distance the crown of the affected trees appeared yellowish green. The pinnae were narrow and tended to bend over or break in the middle. The leaves gradually became smaller than those of the same age on healthy trees, and the blades of the pinnae of the middle leaves dried out, the leaves dropping prematurely. Infected plants were stunted and produced small, short leaves, closely bunched at the end of the trunk. The leaf-dwarfing was followed by gradual tapering of the trunk which finally appeared as a bare, pointed pole. As soon as the pinnae turned yellow, no further fruits were formed, though spathes were sometimes abundantly produced. The racemes (refers to flowers and flower stalks) dried out, but remained on the tree. No organism was found, but the characteristics of the disease are considered to indicate that a virus may be responsible.

It will be seen that there are several features in common with the disease from New Ireland, as, for example, the spotting and frond choking or bunching of the leaves. Nevertheless, the age factor and periodic appearance of the disease in palms which were coming to the bearing stage, and their subsequent recovery as well as absence of the marked tapering stem effects are points of difference which must be noted. It must be conceded also that physiological drought, manurial and rare metal deficiencies may induce similar symptoms to those described.

The occurrences in New Guinea as recorded in palms coming to maturity are closely related to those described by Dr. Jack,(15) and could be termed a "maturation wilt". There is little doubt in the present author's mind that the causes are closely related to those causing bronze wilt and other forms of coco-nut wilt.

Micro-Organisms associated with the Disease in New Ireland.

Plate and slope cultures of the organisms present in all parts of the affected palms were made. *Botryo-diplodia* spores associated with sickle-shaped spores of *Fusarium* spp. were seen. On all the cultures made, a very short bacteria was present which formed whitish colonies, later turning pink in the agar. This bacteria formed a slime (zooglœa) and did not infect the wounded leaves of very young palms.

A species of eelworm was found, associated with the diseased tissue of the leaf stalks, but only a very few colonies were seen. Specimens were prepared and sent to the Imperial Bureau of Parasitology, where Dr. Goodey identified the species as *Cephalobus rigidus,* which is a non-parasitic, saprophagous species of eelworm, commonly occurring in soil, on herbage and in decaying organic matter, and hence was not the cause of the petiole lesions.

Professor Ashby, in referring to the symptoms described (*New Guinea Agricultural Gazette,* vol. 3, No. 1, p. 55), said that "it is possible that the saprogenous *Cephalobus rigidus* might have followed a parasitic nematode. He suggested that "it might be desirable to examine the internal tissues of leaf stalks of leaves younger than those showing external symptoms (dark, depressed streaks and withering)". No parasitic species were, however, isolated after a long and careful search.

Simmonds(27) in 1925 described a form of "bud-rot" possibly due to nematode worms, from Fiji, but, unfortunately, they were apparently not identified. He recorded that "on one occasion a palm was found in Fiji, showing certain symptoms of 'bud-rot', but differing from the typical form in that the central leaf had not wilted and fallen over. Nematode worms were found to be present in vast numbers and were traced from a spot on one of the leaves to the central bud. They seemed in this instance to be the actual causal organisms". It is a pity that it was not determined whether this was a parasitic, or saprophytic species, as the latter would only feed on tissues killed from other causes.

Professor Ashby, Director of the Imperial Mycological Institute,(1) kindly investigated a number of slides, specimens stored in spirit, and cultures forwarded to him.

The following organisms were identified:—

What appeared to be *Aerobacter aerogenes* (Esch.) Cast. Chalm.=(*Bacterium aerogenes* Esch.); a slime-forming, non-motile, non-sporing rod, producing acid and gas clot in litmus milk. This is a bacterium of wide distribution in soil and decaying plant tissue, but is not known to be pathogenic. There was another motile, rod-shaped bacteria (not identified) present, but the *Aerobacter* was the organism which turned up on platings.

Regarding the slide preparations, two scrapings from a nut showed the large septate, brown, striate pycnospores of *Botryo-diplodia theobromae* Pat. about 23-30 x 12-14 microns in size. The fungus is of world-wide distribution in the tropics on a great variety of crop-plants. It is a saprophyte or semi-parasitic entering through wounds, or through lesions caused by other fungi and capable of spreading rapidly in ripe fruits, or debilitated tissues. "Leaf-break" in Ceylon and elsewhere has been attributed to it.

In one scraping from a nut in which the pycnospores of *B. theobromæ* were present and in a scraping from a petiole which was made from a specimen in spirit, a hyphomycetous *(Fungi imperfecti)* fungus occurred with small, hyaline, elliptic conidia, on branched conidiophores. It could not be identified from the slide preparations, but might be recognizable in culture. A preparation from "sulphur-yellow tissue" showed 0-1 septate microconidia probably of a *Fusarium* spp., but no *chlamydospores* were detected.

In another slide (fungus and bacteria from a midrib, unsterilized culture) a fungus was present, in which the cells had separated into "Oidia"; it is probably a species of *Oospora*. Other slides contained bacteria, some being spore-forming. The specimens in spirit do not show anything characteristic of a known disease.

This definite statement by Professor Ashby that the isolated organisms were almost certainly not responsible for the primary trouble was very helpful in turning our attention from any organisms to the climate and soil conditions, where the affected palms were growing.

Nature of the Disease.

The scattered nature of the trouble and its sporadic appearance seemed to discount the fear that an infectious disease was present. It also appeared unlikely that if the disease were infectious to any degree, it would confine itself to palms at a certain stage of development, on a particular plantation.

Even in the earliest reports to the owner, it was stated that, "although fungi and other organisms were present, it was extremely doubtful whether any particular fungi were primarily responsible for the condition". This was borne out by the later investigations. It is well known that weakly, parasitic fungi, also insects, and other organisms have a much greater injurious effect on palms of poor vigour than on normal, healthy palms.

It appeared most likely from the investigations already outlined that the derangements displayed by the palms at Namatanai were almost undoubtedly of a physiological nature.

The necessity for soil analyses and for investigating any particular soil, water-table, climatic, or environmental conditions, likely to lead to upset of the nutritional functions of palms coming to the bearing stage, was also clearly indicated. It was obvious that any deficiency of the soil, especially in major nutrients, would greatly exaggerate any unfavorable environmental factors present.

The analyses carried out at the Waite Institute indicated a certain amount of potash deficiency in the soils where the affected palms were growing. Where the water and nutrient supply to the young palms was reduced by unfavorable soil and water relationships, the availability of the potash to the palm would be still more lessened at the period of greatest demand. Where there is insufficient lime present, as was the case with the surface layer here, the potash would be given up still more slowly.

Particulars of Soil Samples.

The coco-nut palms which grow in the Namatanai district of New Ireland appear to flourish generally, although there are a few very old plantations in this area to indicate how they will fare when they reach an advanced age. The indications are, however, that they will last as long as in most districts here, despite the apparent shallow depth of soil, before coral is reached, in some places. The soils on the plantation under investigation are undoubtedly of a residual nature, being for most part derived, *in situ,* from uplifted coral. In some areas there is possible admixture of some top soil washed down from the high hills behind, but the soils are mainly of coralline derivation.

Profiles from three situations in the one plantation were submitted for analysis. In the "X" series, the hole was sunk on a fairly raised area, away from the foreshore, where the underlying coral was met closer to the surface.

In the "Y" series, the soil samples were taken from a spot lower down in a depression. In this position, the red, underlying sub-soil was deep and a hole had to be sunk several feet before any coral was reached.

The single sample "1Z" represents a different type of sub-soil which was met about 100 yards nearer the foothills than the position where the "X" series was obtained. This was more yellowish in colour, although the texture appeared much the same as the other sub-soils submitted.

The appearance of the affected palms and the accompanying symptoms, soil conditions, &c., have previously been described, as mentioned elsewhere.(9)

Report on Soil Samples from New Guinea.

(New Ireland District.)

By J. S. Hosking.[*]

2. SOILS FROM A PRIVATELY OWNED PLANTATION, NAMATANAI SUB-DISTRICT, NEW IRELAND.

Two profiles and a further sub-soil sample from a privately-owned coco-nut plantation situated in the Namatanai sub-district on the island of New Ireland have been examined and the results are appended.

The two profiles from this coco-nut plantation are similar, and consist of red-brown extremely heavy clays throughout their whole depth. In the surface layers, which are darkened by organic matter, the clay contents are 62 and 79 per centum respectively and the content rises to about 90 per centum in the sub-soils. In profile "X" the clay sub-soil overlies a layer of soil, admixed with nearly 70 per centum of the parent coralline limestone. In the sub-soil "Z3" the colour is yellow to yellow-brown and the clay content also about 90 per centum. A coarse sand, fine sand, silt ratio, approximating to 1 : 3 : 6 for all the samples, indicates an essentially similar origin for the materials at all three profiles. The somewhat lower clay contents of the surface horizons show that some eluviation has taken place in both profiles.

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[*] Of the Division of Soils, Council for Scientific and Industrial Research, located at the Waite Institute, South Australia.

Although the mechanical analyses of the soils (*see* Table 2) would appear to class the soils as heavy clays, their physical properties indicate that in the field they would act as much lighter soils in a similar manner to the red loams of eastern Australia.

The soils are acid in the surface and in the absence of limestone close to the surface, increase in acidity with depth. In the limestone layer, however, the soils become distinctly alkaline.

They are well supplied with both nitrogen and phosphoric acid, but potash is low throughout the profiles. The low values for potash, considering the high content of clay, show a further similarity to certain of the Australian red loams.

TABLE 2.—MECHANICAL ANALYSES AND CHEMICAL DATA FOR SOIL SAMPLES FROM A COCO-NUT PLANTATION, NAMATANAI SUB-DISTRICT, NEW IRELAND, TERRITORY OF NEW GUINEA.

Site.	X.				Y.			Z.
Sample Number.	1.	2.	3.	4.	1.	2.	3.	3.
Waite Institute Sample Number.	5390.	5391.	5392.	5393.	5395.	5396.	5397.	5398.
Depth in Inches.	..	..	..	..	..	..	..	..
	%	%	%	%	%	%	%	%
Coral limestone	..	..	..	63.7	..	..	..	..
Fine earth	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Coarse sand	1.0	0.7	0.3	0.2	2.4	1.0	0.2	0.2
Fine sand	3.5	2.0	1.1	0.5	8.4	3.5	1.0	1.6
Silt	7.3	5.0	3.7	0.8	20.1	10.1	2.2	3.0
Clay*	78.6	85.2	88.8	40.2	62.4	79.4	90.0	89.0
Loss on acid treatment ..	1.7	1.6	1.9	56.3	1.6	1.1	1.4	1.1
Moisture	5.5	5.1	5.3	2.5	5.7	5.6	6.0	6.1
Loss on ignition	19.1	17.2	16.1	..	16.5	15.5	14.5	13.2
Phosphoric acid P_2O_5	0.32	0.29	0.32	..	0.28	0.27	..	0.41
Potash† K_2O	0.03	0.03	0.04	..	0.04	0.04	..	0.06
Nitrogen N	0.27	0.25	0.15	0.10	0.22	0.15	0.14	0.10
Soil reaction pH	6.1	6.0	6.7	8.3	6.5	6.1	5.7	5.1

* Note high content. † Note low content.

" Frond Choke " and " Die-back " of Coco-nuts.

(*Comments by Mr. Hosking.*)

"It is unlikely that the diseases of coco-nuts at either the Kokopo Plantation, mentioned in the earlier report, or the particular plantation in Namatanai, which form the subject of this report, are the result of major plant nutrient deficiency, since, apart from the low content of potash in the latter soils, all soils examined are very well supplied with them. At the same time, the probable importance of minor elements must not be overlooked.

"After reading through the various reports by Mr. R. E. P. Dwyer, either published in the *New Guinea Agricultural Gazette* or forwarded with the soil samples, and, also, following a discussion of the problem with Mr. D. B. Adam, Plant Pathologist at the Waite Institute, it would appear that there is more than a chance resemblance between the 'frond choke' and 'die-back' described in New Guinea and the 'bronze-leaf wilt' described by Briton-Jones(4) (also Bain(2)), in Trinidad. [Their findings are detailed in a later section of this article.]

"The common feature is the general wilting of the young, shallow-rooting coco-nut palms after long spells of dry weather, with, usually, subsequent recovery following general rains.

"While this feature has usually been observed only on light soils, it does not preclude a similar occurrence on the Namatanai type of soil, despite its apparent heaviness.

"Water-holding capacity determinations indicate that under conditions which restrict or entirely prevent drainage, the soils from Kokopo will absorb from 60 to 100 per centum of their own weight of water, and the Namatanai soils examined from 65 to 90 per centum. The Kokopo soils are extremely porous and the sandy nature of the sub-soils allows the water to drain away rapidly. Dwyer has indicated in his report in the *New Guinea Agricultural Gazette*, 1938, Vol. 3, No. 1, p. 56, that the soils on this particular plantation at Namatanai are readily penetrated by water and the extremely cavernous nature of the underlying coralline limestone will, therefore, allow of just as rapid drainage as in the case of the lighter Kokopo soils. During periods of drought, therefore, both types of soil will dry out rapidly, especially in the surface layers, and the shallow-rooting young coco-nuts are, therefore, the more likely to be affected. Following heavy rains, the high water-holding capacities allow the soils to regain their normal moisture status and restore the water balance in the palm."

The present writer comments that it will be seen from the various reports, of which these analyses form a part, that these comments by Mr. Hosking are a valuable contribution towards the solution of the nature of the coco-nut disease at Namatanai. It is pointed out, however, that the pathological symptoms of the occurrence in New Ireland are much more complex than those at Kokopo, New Britain, and, undoubtedly, other factors are involved. There has been further work done on the occurrence from Namatanai, since the publication in the *New Guinea Agricultural Gazette* mentioned, and, in this regard, the comments of Professor Ashby, Director of the Imperial Mycological Institute,(1) also those of Dr. Ocfemia,(19) of the Philippine Islands, are most enlightening, and show that the issues are not so clear as it may appear.

The indication of a low percentage of potash in the Namatanai soils is most important in view of the conclusions of Bain, F. M.,(2) on his work on the causes of "bronze-leaf wilt" disease of the coco-nut palm in Trinidad, of which a *Review of Applied Mycology* review is given verbatim. It may be noted, however, that the disease in Trinidad has apparently not been always associated with coco-nut palms coming to the bearing stage, as seen in New Guinea at Kokopo, Namatanai, near Kieta on Bougainville Island, and elsewhere. The causes underlying the similar occurrences recorded by Jack in Malaya(15) may be closely related to what has been found in these present investigations.

As pointed out in the remarks on the plantation at Kokopo, the poor type of seed nuts used in that particular area, as well as the presence of "kunai" or "Alang Alang" (*Imperata arundinacea*), in the early stages, were contributing factors to the poor condition of the palms. Such circumstances rendered them more susceptible to any unfavorable soil and moisture relationships which may exist in times of drought, or when the palms are coming into bearing.

Particulars of Rainfall.

Unfortunately rainfall records have not been kept at the particular plantation from which the "maturation wilt" was recorded. Records kept at the Namatanai Government Station, which is only a few miles away, have, therefore, been consulted.

NAMATANAI RAINFALL.
(*See* Graph.)

—	Average for 21 years.	1936.	1937.	Rainfall wet season, average 21 years.	Rainfall dry season, average 21 years.
	Points.	Points.	Points.		
January	15.23	20.93	19.96	*	†
February	17.34	15.18	15.14	15.23	8.64
March	16.07	20.12	19.85	17.34	7.49
April	13.79	7.11	12.44	16.07	8.84
May	8.64	7.00	7.14	13.79	6.75
June	7.49	2.60	4.29	11.37	5.33
July	8.84	6.24	6.77	17.14	8.74
August	6.75	14.18	12.18	..	..
September	5.33	5.20	8.06	..	..
October	8.74	12.66	6.17	..	..
November	11.37	17.21	11.47	..	..
December	17.14	14.26	19.96	..	..
Total	136.73″	152.59″	143.43″	90.94″	45.79″

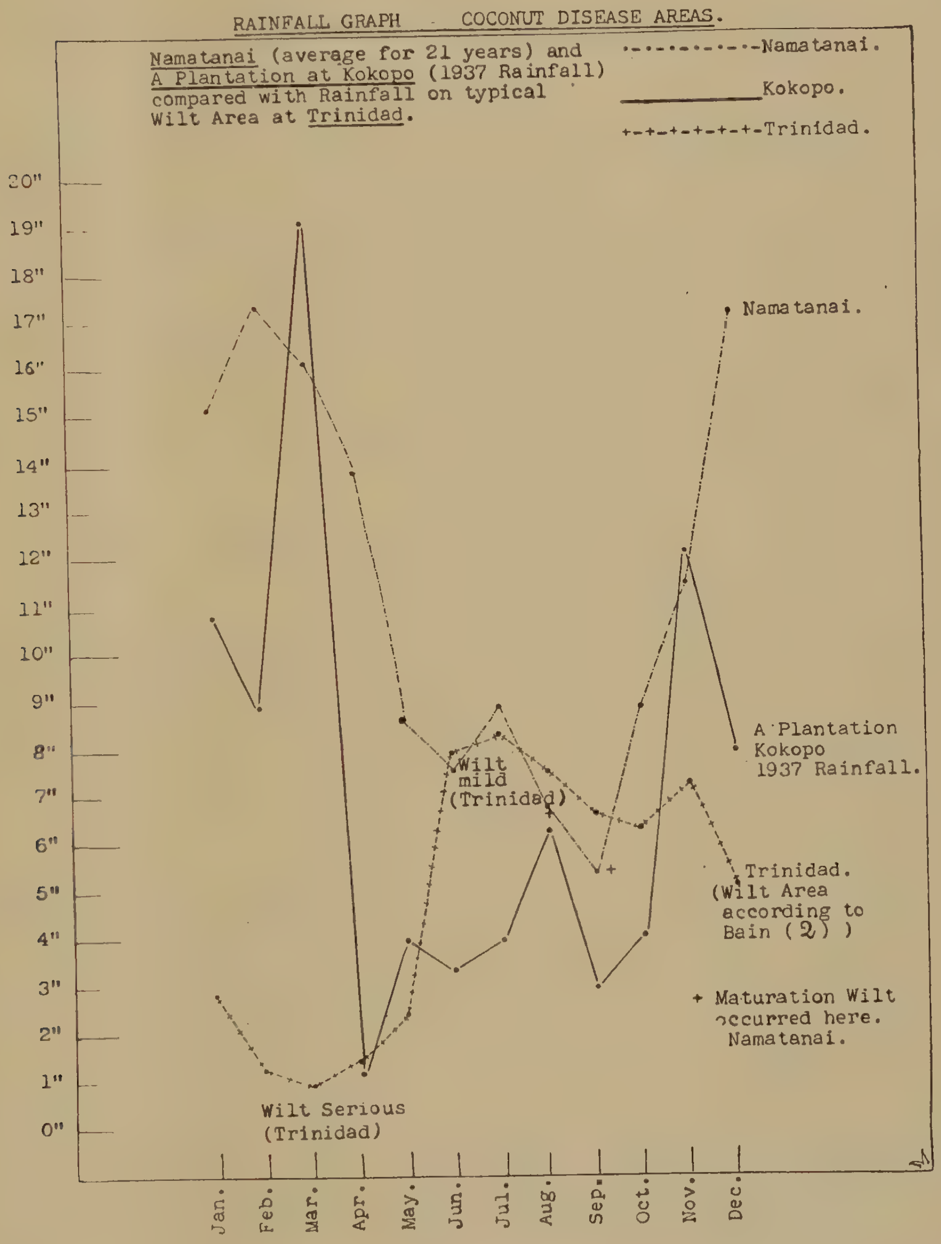
* November-April inclusive. † May-October inclusive.

It will be seen from the above records that the rainfall should be ample for coco-nuts. The wet period in this district is from November to April. There are six dry months of which the driest month is September—August ranking next. It will be noted that about twice the normal August rainfall was recorded in 1936 and 1937. Abnormal rainfall periods occurred in June, 1935, when 141 points of rain only were recorded, and curiously in June, 1936 (260 points) and June, 1937 (429 points) abnormally low rainfalls were again recorded. It will be seen that the rainfall for both these years was heavier than average, so that the contrast between the wettest and driest months is much greater than normal.

The contrasts between the wet and the dry seasons here are not nearly so great as that in the Madang District, or in parts of New Britain, for example, where sometimes eight times as much rain falls in the wet season as in the dry season. This was one of the considerations which led one to think the young palms would recover as soon as conditions become normal.

The fact that in New Guinea coco-nut palms are generally grown under much wetter rainfall conditions than those which prevail in many other parts of the world may have some bearing on the relatively limited occurrence of physiological, or true, drought wilts here. The land here has not been in cultivation for such long periods as in other parts of the world (such as the West Indies) and this would also greatly lessen the chances of wilts occurring here.

The rainfall distribution at Namatanai is compared (*see* graph) with that of a typical bronze wilt area in Trinidad, shown diagrammatically by Bain.(2)



It is seen that in the wet season he depicts, they would generally receive less rain than in a typical dry season at Namatanai. It would appear, however, that, although the rainfall is much heavier, the fluctuations from the wet to the dry season are more marked in the latter instance. According to Bain, in a typical wilt area in Trinidad there is a marked dry season—February, March and April being particularly dry. From May onwards precipitation there is quite large (in comparison); the amount commences to decrease in December.

Earlier Incidences of the Disease.

It is pointed out that a "die-back" condition at maturity, as described, is not new to coco-nut palms in the Namatanai district, as was generally stated by the planters there. It was recorded from two plantations in 1923, when these plantations were at a comparatively young stage. The Entomologist of this Department, Mr. J. L. Froggatt, briefly described the same condition from the particular plantation under investigation on 26th November, 1934 (unpublished information), and the following remarks are quoted verbatim from his diary:—

> "*Coco-nut Dieback.*—On the affected palms, one frond emerges and is apparently choked while the pinnae (leaf division) appear black where this occurs. The following frond becomes smaller and more choked and finally the folded pinnae appear as completely blackened. According to the owner, the palms may be killed if not cut back to the fresh tissue, above the cabbage, and tarred."

The palms were about four to five years old, and some were carrying their first nuts. He was also informed at the time of his visit, that the condition had been seen before on this same plantation.

Nature of the Disease at Namatanai.

In the 1936-37 Annual Report (*see* also League of Nations Report, p. 83, 1936-37),(17) the following notes are given:—

> "Physiological diseases of coco-nuts were investigated at Namatanai. This rather obscure disease has been noticed here since 1923. It is apparently physiological and due to unsuitable soil and climatic conditions, while the palms are at the critical bearing period. Palms coming into the stage of maximum maturity have been noticed to suffer a physiological set-back, which often affects the production for upwards of two years. This has been noted here on several occasions, similar occurrences have been noted from Malaya,(15) and it is most prevalent on certain types of soil under particular climatic conditions."

In the Departmental Annual Report for 1937-38, the disease was again mentioned as follows:—

> "Professor Ashby considered that, amongst other possibilities, the physiological disease present in coco-nuts just coming into bearing may be identical with the 'cadang cadang' disease described by Ocfemia in the Philippines,(19) and believed to be a virus disease. In August, 1937, this physiological 'set-back', as described in the last annual report, was again seen at Namatanai in palms reaching the bearing stage, but the fact that the palms soon recovered, when conditions were favorable, seems to show that the condition is physiological and is influenced by the extra demand for water and nutrients not being met under certain dry weather conditions on a heavy soil, at this critical stage."

It therefore appears that the reduced nutrient supply to the developing palms and fruits follows on the reduced water supply in the dry season at a time when the demand for nutrients is greatest. No doubt the effects were exaggerated by the deficiency of potash recorded. The contention that this may be a virus disease cannot afford to be overlooked, but the present author does not believe that this is the case in this particular instance. This opinion is based on the fact that the palms usually recover and do not often show a recurrence in the same area. There is little doubt that virus diseases are present on coco-nut palms here, as was recorded in the earlier article,(9) but, so far, no work has been done to indicate the importance of these types of diseases in coco-nuts.

Coco-nut Palms Showing " Frond Choke " and Bearing Poorly.

Kokopo District—New Britain.

*(Report by the Economic Botanist.)**

On two distinct sections of an extensive plantation at Kokopo, New Britain, a large proportion of the coco-nut palms growing there presented a "frond-choked" appearance, and were bearing rather badly when visited first in November, 1937. The palms in these areas were either just past the first bearing stage, or, in other instances, had been bearing for no more than three years.

It is not uncommon for coco-nuts which have just reached the bearing stage, or have been in production for two or three years only, to show evidence of "frond choke" and similar disorders. In many parts of this Territory coco-nut palms have been noticed to suffer a physiological set-back at this stage, which often affects their production for two years or more. This has also been reported from Malaya, and is most prevalent on certain types of soils under particular climatic conditions. As for example, it has been seen on comparatively rich soils on young bearing palms after a dry spell following a wet period. It must be remembered that palms reaching the bearing stage are at a physiologically critical period, owing to the extra strain placed on the plant, and the increased call for nutriment, at this period, seems to place an extra strain on the plant, which becomes apparent when, for any reason, the conditions are not entirely favorable. It is a fact that certain types of palms are more liable to this "frond choke" condition than others, and usually they can be distinguished by their erect, close growth of narrow fronds, which appear to have a rather feathery appearance. In other words, there does appear to be an hereditary tendency for palms to show this undesirable type of growth.

In order to make certain whether or not the palms at this plantation were suffering because of natural soil conditions, soil samples were taken from a couple of widely-spaced areas where the palms were worst, and despatched to the Waite Institute, Australia, for analyses.†

The actual methods of planting at the particular sections of the plantation in question are not known, and probably planting was carried out roughly in the first instance. The source of the seed coco-nuts used was, undoubtedly, from local, unselected, native palms, and it is fairly safe to assume from the appearance of the palms and the nuts which they are bearing that no systematic seed selection of any kind was carried out. In this way, a large proportion of poorly vigorous palms can be perpetuated, which is often done because, in the first instance, the planter wishes to get his original seed nuts as cheaply as possible. Some individuals in this Territory have used germinated (or "krued") nuts without having the slightest idea from what kind of palms they were derived.

It must be mentioned, however, that some experienced planters here have referred to another cause of "frond choke" in palms. Its development has been noticed in rows where the natives, in the course of planting, had split the nut and detached the young plant—"krue"—from the nut, and eaten the kernel, and, probably, the endosperm. They have even been known to dig up the nuts and eat this portion after they have been planted out, and then place them back in the same hole. The edible part is much prized by natives and it is likely that, at times, natives would eat this delicacy on new plantations unless they are closely watched. When there are no other groves in the vicinity they, of course, follow the easiest way to augment their rations. This is not common where proper supervision of the plantings is attended to.

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* Original report to owner by the author.

† The reports on soil samples from Kokopo by Mr. J. S. Hosking refer to these.

It is believed, however, that the original seed coco-nuts were at fault in the affected areas, though it is very probable that the palms growing there will improve when they grow older.

As the owners are still planting up large areas, it would be preferable to obtain seed nuts from a bearing plantation which was known to be derived from selected nuts in the first instance, and, in this connexion, particular plantations in Kar Kar Island were mentioned by the owners as being suitable places from which to bring in seed nuts.

It is well known that Kar Kar nuts are noted for their size and weight, and there is a distinct possibility that they are the result of some original selection in the first instance.

It must be remembered, however, that the development of nuts on Kar Kar may be largely due to the environment. If it happens that the palms there represent a selected, or distinct, regional strain, that gives more chance of success. Some authorities, such as Sampson,(25) say that it is best to select good palms from areas where the soil approximates that where the palms are to be grown. Smith,(29) in Malaya, worked it out that it was best to select from the heaviest yielding areas which could be found, so that the chances were greatest of only good palms crossing amongst themselves. This is a complicated subject which is elucidated in an article on "Coco-nut Improvement by Seed Selection and Plant Breeding".(11) (See *New Guinea Agricultural Gazette*, Vol. 4, No. 3, p. 24.)

A common method of selecting seed nuts here is to select them from heaps gathered for copra cutting, and, in this instance, good, round, heavy nuts are usually, but not always, selected. This type of selection is definitely better than none at all, because the chances are high that good nuts would be obtained from good palms.

The great objection to the selecting of coco-nuts from a garnered heap is that one has no knowledge concerning the good points, or defects, or of the appearance and types of individual palms from which such seed coco-nuts were derived. A poor looking and weak palm may, in some instances, bear a very few good, shaped nuts, which would be selected from the heap and thus perpetuated.

A few of the most experienced planters in New Guinea have marked individual palms on old plantations and observed them singly for use as mother-palms for the production of seed nuts, as it is believed has also been done on some company plantations here. The idea, of course, is to select heavy bearing palms, and then to eliminate any uneconomic types. But all coco-nuts are the products of cross-fertilization, and, although the seed nuts are derived from good palms, they do not necessarily breed true. The nuts from some palms are known to give a lower percentage germination than those from others, which is an hereditary tendency, and such palms should be avoided.

Selection in the nursery is not only desirable, but necessary, and only seedlings should be taken which are strong, sturdy and healthy. All inferior types and non-germinated nuts should be entirely discarded. It must be remembered that, as the seed nuts are the product of cross-fertilized flowers, regardless of the outside appearance of the nut, the seedlings derived from any one palm will display considerable variation. Long, rangy plants, or plants having a tendency to yellowing (chlorosis), should be avoided. Leggy, poor type seedlings can never produce good type palms, neither can those which are twisted or sickly.

It is also quite certain that, in addition to the above precautions, selective replantings in the field are a payable proposition, because it is not possible to separate out all the plants which are not likely to thrive from nursery selection alone. All plants which are not thriving and all misses in the planted areas should be replaced with strong, sturdy replants, and the best time for replanting is while the surrounding palms in the plantation are still young, and not too tall or well-developed, so that the replants receive little root competition, &c., and no excess shade. Any injuries to the young seedlings during replanting, or to the growing point by insects, rats, or animals in the young stages, provide a serious set-back to the plants for all time. Injured plants should be replaced as soon as they are noticed, and at as early a stage as possible.

The next important recommendation is that a substantial percentage over and above that just barely required to plant a certain area should be set out in the nursery. This, again, appears costly, but it is money well spent when it is remembered that the palms will be growing for over 50 years. Finally, if the owner-company has found that palms on any of their plantations are from nuts of good strain, well selected in the first instance, they are the ones recommended for use as a source of seed nuts. It is not now possible to say how coco-nuts from Kar Kar Island shifted to this Kokopo plantation will thrive, but probably they would be quite all right judging by experiences elsewhere.

All of the later plantings made by the owners, and these comprise the bulk of the planted areas, have been made with selected seed nuts under good, practical supervision. The difference between these well-planted palms and those seen on the earlier-planted areas is most strikingly in favour of the well-selected and properly-planted nuts.

The areas in question were recently visited—just twelve months after the report was made—and the improvement in the affected palms, especially those growing on one area, was clearly evident. There is still a proportion of the palms showing "frond choke" and "yellowing" plus a tendency to "leaf-droop".

The palms which have improved least of all are those which are in an area which was said to have been badly overgrown with "lalang" or "kunai" grass, *Imperata arundinacea,* in the early stages, and most of which has since disappeared. The fact that the ground, at this particular spot, is undulating, and that closely-spaced, almost parallel tributaries running into a deeper stream are present, may increase the drainage and water run-off, and thus affect the palms growing on this light soil.

Reference should be made to the rainfall graph (page 45), where the rainfall for the year 1937 at the Kokopo plantation under investigation is compared with that of Namatanai, and a typical wilt area in Trinidad. It will be seen that this was a year of severely fluctuating rainfall, as, for example, compare the 19 inches recorded in March with the little 1 inch rainfall recorded in April, or the 3 inches in September with the 12 inches in November. One could expect physiological derangement of young bearing palms where a seven months' dry spell was experienced on the porous soils described, i.e., apart from the other contributory factors present.

Report on Soil Samples from New Guinea.*

(New Britain District.)

(By J. S. Hosking.)†

" Soil samples, representing two profiles from the coco-nut plantation in the Kokopo District, on the Island of New Britain, have been examined and the results are appended.

1. *Soils from Backward Area of Coco-nut Plantation, Sub-district of Kokopo.*

These soils have formed on geologically recent, layered deposits of volcanic ash, very similar to the deposits resulting from the recent volcanic eruptions at Rabaul and, like the Talasean soils, are extremely immature in their development. The deposits are of the pumiceous type, but show only a small proportion of pumiceous stone, about 3 per centum in the lower layers of the second profile.

The profiles consist of about 12 inches of a dark grey-brown to grey-brown clay loam to light clay, rich in organic matter overlying, in the case of (1) a light grey-brown clay loam to a depth of 42 inches, and in (2) a light grey-brown loam to 24 inches over a grey, passing to grey-white, pumiceous sand. Except for the sandy layer of the second profile, these soils have a distinctly silty feel and might well be classed as silty clays or silty loams.

Both profiles show reaction values which vary little from neutrality (pH 7) throughout their depth.

The surface soils are well supplied with plant foods, the nitrogen, phosphoric acid and potash contents showing average values of 0.4 per centum, 0.2 per centum and 0.3 per centum respectively. In the sub-soils, while the nitrogen content decreases rapidly, phosphoric acid and potash show only slightly diminished values.

Mechanical analyses and chemical data for these soils are given in Table I.

Water-holding capacity determinations indicate that under conditions which restrict or entirely prevent drainage the soils from Kokopo will absorb from 60 to 100 per centum of their own weight of water. The Kokopo soils are extremely porous, and the sandy nature of the sub-soil allows the water to drain away rapidly.

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* Abstract from a general report including other soil samples.

† Of the Division of Soils, Council for Scientific and Industrial Research, located at the Waite Institute, South Australia.

It is unlikely that the 'frond choke' conditions of the coco-nuts in this section of the plantation are the result of major plant deficiency, since all the soils examined are well supplied with plant nutrients.

A feature which is usually observed on light soils is the general wilting of the young, shallow-rooting coco-nut palms after long spells of dry weather, with, usually, subsequent recovery following heavy rains. During periods of drought this type of soil will dry out rapidly, especially in the surface layers, and the shallow-rooting, young coco-nuts are, therefore, the more likely to be affected. Following heavy rains, the relatively high water-holding capacities allow the soils to regain the normal moisture status and restore the water balance of the palms."

Mr. Hosking's remarks on the comparison of the soils showing the described symptoms in coco-nut palms at Kokopo with soils growing palms similarly affected at Namatanai, New Ireland, are included earlier with a more detailed pathological description of the latter occurrence by the Economic Botanist.

TABLE 1.—MECHANICAL ANALYSES AND CHEMICAL DATA FOR TWO SOIL PROFILES FROM A SECTION OF AN EXTENSIVE COCO-NUT PLANTATION, KOKOPO DISTRICT, NEW BRITAIN, TERRITORY OF NEW GUINEA.

Site Number	1.			2.			
Sample Letter.	A.	B.	C.	A.	B.	C.	D.
Waite Institute Sample Number.	5382.	5383.	5384.	5385.	5386.	5387.	5388.
Depth in Inches.	0–12.	12–24.	24–36.	0–12.	12–24.	24–36.	36–42.
	%	%	%	%	%	%	%
Pumiceous stone	..	..	..	..	..	3.4	2.4
Fine earth	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Coarse sand	4.1	8.2	15.4	7.1	19.6	31.9	33.6
Fine sand	22.4	26.9	31.2	26.3	38.4	45.4	43.0
Silt..	30.1	33.0	26.4	29.3	25.0	16.2	14.3
Clay	28.9	21.2	22.3	22.7	11.0	4.8	5.8
Loss on acid treatment ..	4.1	2.9	1.4	3.7	1.8	1.1	0.4
Moisture	8.4	6.7	4.0	7.3	4.0	1.0	2.6
Loss on ignition	13.7	9.4	6.5	12.7	5.9	3.0	2.6
Phosphoric acid P_2O_5	0.21	0.10	0.03	0.21	0.15	..	0.13
Potash K_2O	0.26	0.27	0.14	0.35	0.34	..	0.28
Nitrogen N	0.42	0.20	0.08	0.36	0.08	0.03	0.01
Soil reaction pH	6.9	6.9	6.9	7.1	7.0	7.4	7.3

Other Records of Maturation Wilts in New Guinea.

Inquiries and personal observations lead one to the conclusion that there are few plantations in New Guinea where some areas of coco-nut palms do not display symptoms of nutritional disturbances, to a greater or lesser extent, when they are coming into bearing.

In Bougainville Island, near Kieta, the author saw palms at this stage which were similarly affected to those at Namatanai, except that the disease was not so serious and the palms later recovered without any considered treatment on the part of the owner. In this case the areas affected were some 60 feet above the level of a small river and, as the ground was very free working, the water, apparently, got away easily. A good deal of pumice was mixed in with the soil. The fronds showed the same distinct spotting as was seen in the fronds from New Ireland and, also, a certain amount of tip-wither and leaf-break.

It was also seen that scale and mealy-bug insects were prevalent, especially one described by the Imperial Institute of Entomology for the Entomologist as a completely new genus, as yet unnamed. Also *Aspidiotus destructor* (red scale) and many colonies of *Aleurodicus destructor* were seen, together with a good deal of *Pestalozzia* spotting. The striking feature was the manner in which the various pests appeared to concentrate on the poorly vigorous palms. These palms were seen in the dry season, and later on, after heavy rains, were said to recover to a very large extent.

Since that time careful observations on several plantations, where palms were just coming into bearing, have shown that, in most places, patches are present in which the fronds show a typical yellowing or spotting, just as in the cases described. In some instances this is only apparent to a keen observer who is on the look out for the condition, and may pass unnoticed by the planter on the spot. This is mainly because, in such cases, the change in colour is not very great, and, secondly, because the symptoms disappear as soon as the climatic conditions improve and the stage of maximum nutrient requirements is passed.

In the same plantation it has been remarked, on numerous occasions, that palms on areas which have previously grown native foods or are planted over old native gardens present the worst appearance at the critical stages. It will be shown that there are sound chemical and physiological reasons for this being the case. Any retarding of the nutrient and water supply to the plant will have a quicker and more decided effect on palms growing on soils already exhausted, to a large extent, by previous cropping.

Observations have already shown (also recorded from other countries) that the effects of drought are greater on young palms than on adult palms.

Maturity of Coco-nut Palms in Malaya.

Dr. Jack(15) has made the following interesting comments concerning coco-nut palms coming into bearing:—

> "Individual palms vary in the age at which they reach maturity, although field observations reveal no difference in growth.
>
> On flat, alluvial land in this country (i.e. Malaya), it is commonly noticed that young palms, usually about ten years old, which have yielded well for two or three years, sustain a set-back and produce poorly for one to two years before again yielding good crops.
>
> This habit is possibly an environmental effect resulting from a high water-table, which probably arrests the development of the natural root system temporarily, causing a shock which retards the growth for a time. The habit is, however, also recorded on estates which maintain a fairly low water-table (4 feet or more), so that it may be merely a growth character, marking the period after which the palms may be said to be mature."

It will be seen that this description fits several similar occurrences recorded in New Guinea.

Wilts at Maturation Period Compared with Wilting in the Mature Stages.

Were the disease in Namatanai to occur in the West Indies and elsewhere, it seems most probable that this type of disease which is herein tentatively referred to as "maturation wilt", would be classed in the same category as "bronze wilt" and as influenced by the same limiting factors. The disease at Namatanai seems, however, to be a more temporary derangement, and the necrotic spotting and streaking of the midribs appear to differentiate it.

It appears to us that this type of "die-back" is of a closely related type. It must be recognized that in a young palm just reaching the bearing stage there are several other contributory and interlocking, limiting factors acting which are not present in the same degree, once the palms have settled down to permanent bearing. The chemical composition, the relative amount of dry matter to moisture present, the root system and the economy of a young palm are quite different from that of an old, fully-bearing palm. As laid down for "Vernalization" procedure, it is necessary to distinguish between development and growth, and, as the plant develops from germination to maturity, it goes through several distinct stages. It stands to reason that the behaviour, or reaction, of the palm at one stage (in this case a critical stage in its life cycle, that of coming into bearing) to its environment is not the same as the reaction of an old palm to the same soil and climatic environment, e.g., the young palms are more susceptible to drought.

It will be seen from descriptions given later on, and references quoted,(4-2-8) that in the West Indies there is a tendency for coco-nut wilts to occur frequently in young palms, but one has seen no account of the disease appearing at such an early stage as was recorded at Namatanai.

The advisability of distinguishing "maturation wilt" from more permanent and serious "mature palm wilts", such as those described from New Guinea, in the latter portions of this article, must be considered.

In the next issue of this *Gazette,* the occurrences in New Guinea are compared with similar physiological diseases of coco-nuts recorded from other countries. The chemical and physiological changes which occur in coco-nut palms at various stages of growth are also discussed, in relation to the diseases described from New Guinea and elsewhere.

The importance of proper cultural conditions for the control of most coco-nut diseases, particularly those of physiological origin, is also stressed.

(*To be continued.*)

COWPEAS (*Vigna catiang*) AS A GREEN MANURE AND COVER CROP.

By George F. Gee, H.D.A.

The value of cowpeas (*Vigna catiang*) as a green manure and cover crop is not fully realized by planters in this Territory, where a quick-growing plant is required to cover the soil, and so prevent the growth of weeds, grass, &c., and at the same time to provide a large bulk of nitrogenous material which is valuable as green manure.

The plant, which comes from India and China, is an annual bean-like plant and provides excellent pasture, good hay and ensilage, especially when grown in conjunction with other crops, such as maize, sorghum, or millet, but is best known for its value as a green manure.

In the southern States of the United States of America, cowpeas hold an important place in agriculture, because of the high yield of forage obtained and the seeds, which closely resemble field peas in composition, are fed to all classes of animals.

Henry and Morrison,(4) in the following table, give the composition of cowpeas seed as compared with corn, wheat, rice, barley and field peas.

—	Digestible Crude Protein.	Digestible Carbohydrates.	Digestible Fat.	Total Digestible Nutrients.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	1 :
Cowpeas	19.4	54.5	1.1	76.4	2.9
Corn	7.5	67.8	4.6	85.7	10.4
Wheat	9.2	67.5	1.5	80.1	7.7
Rice	4.7	64.6	1.7	73.1	14.6
Barley	9.0	66.8	1.6	79.4	7.8
Field peas	19.0	55.8	0.6	76.2	3.0

This shows cowpea seeds to be very high in their protein content, and to possess a very narrow nutritive ratio, so that when being fed to stock they would need to be fed in conjunction with a food rich in carbohydrates.

Like most crops, cowpeas do best in good soils, but they will grow on almost any soil providing the drainage is good. On poorer soils, their growth is superior to many crops and there is a tendency for the plant to produce less foliage, but a greater yield of seed pods. The best type of soil is that which is suited to maize and preparation of the seed bed is similar; in fact on the north coast of New South Wales these two crops are largely grown together when the maize is being grown for ensilage. In this case, the cowpeas are sown after the last cultivation of the maize crop, just prior to tasselling. In this way the nitrogen content of the soil is maintained and the quality of the ensilage is improved since it has a higher protein content than maize alone.

The seed should be sown in a fine, warm, moist seed bed and no difficulty will be experienced in establishing the crop. The plant will not stand cold weather at high levels but in coastal districts will stand up well to periods of dry weather. The seed may either be broadcast or sown in rows 3 feet apart and the seeds

6 to 9 inches apart in the rows. According to the variety (as the seeds vary in size according to the variety) ½ to 1 bushel of seed is required, if broadcast, and 10 to 15 lb. if in rows, to plant an acre. A bushel of cowpea seed contains 60 lb.

There are numerous varieties of cowpeas, the seeds of which are found in all plain colours and speckled or marked. The best and most popular varieties are Black, New Era, Victor and Whippoorwill.

Black is one of the oldest varieties and is probably grown more than any other. It is late maturing and produces a great bulk of green material. The vines are semi-procumbent in habit, and they bear large pods up to 9 inches in length containing large black seeds. These large pods, which ripen fairly evenly, are an advantage when harvesting the pods.

New Era is a much newer variety than Black and has the advantage of being resistant to wilt. It is much earlier in maturing than Black and produces almost an equal amount of green stuff. The pods are medium large and plentiful and are borne well up off the ground.

Victor is very resistant to wilt and resembles closely New Era except that it is a late maturer and at times a very shy bearer.

Whippoorwill bears medium large pods in great quantity. This variety has proved at Keravat Demonstration Plantation to be practically equal to Black in the bulk of green material produced and is well worth consideration.

Early varieties mature their pods in 70 to 90 days from planting and the crop may then be turned in or cut for hay, but the harvesting may be delayed much longer without appreciable loss.

Cowpeas are claimed in the United States of America to produce from 1 to 3 tons of hay per acre and are an excellent fodder for cattle, horses and sheep.

The following table(4) gives a comparison of the two legumes, lucerne and cowpeas, when fed as hay:—

——	Digestible Crude Protein.	Digestible Carbohydrates.	Digestible. Fat.	Total Digestible Nutrients.	Nutritive Ratio.
	Per cent.	Per cent.			
Lucerne	10.6	39.0	0.9	51.6	3.9
Cowpeas	13.1	33.7	1.0	49.0	2.7

Where lucerne can be grown it is superior to cowpeas for hay and has the advantage of being more easily handled and cured. Cowpea hay is difficult to cure, but will withstand more rain than most hay crops during the curing period. In the southern States of America, cowpea hay is grown as a substitute for lucerne hay in areas of high rainfall, similar to the north coast of New South Wales.

When grazed cowpeas have a high feeding value and by first feeding off and then turning the crop under, much of the manurial ingredients is returned to the soil. Feeding off makes it easier to turn the crop under and decomposition takes place more rapidly.

Pigs like cowpeas and do well on them but it takes a little time for cows to become accustomed to them.

As a green manure crop, cowpeas are extensively grown in the sugar-cane districts of Queensland, and are also becoming more popular in a crop rotation with maize, this being practised on the north coast of New South Wales.

When a crop is turned in for green manure, decomposition takes place and humus is formed. This humus supplies plant food, improves the soil's texture, prevents too rapid evaporation of soil moisture and helps the soil to absorb and retain water. This decomposition also results in the formation of carbon dioxide which forms a weak acid (carbonic acid) in conjunction with water. This helps to break up the soil and to make available the plant food contained in it.

The following table(3) shows the amount of fertilizing ingredients added to the soil by ploughing under certain green crops:—

—	Average yield per Acre.	Percentage composition of whole plant.				Amount of fertilizing ingredients added to the soil in pounds per acre.		
		Water.	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.
	Tons.							
Cowpeas ..	7½	84.4	0.63	0.13	0.46	106	22	77¼
Oats ..	8	75.0	0.72	0.19	0.56	129	34	100½
Rye ..	8	81.9	0.32	0.17	0.60	57½	30½	107½
Red clover ..	2	70.8	0.54	0.12	0.67	24	5½	30
White clover	2	80.0	0.43	0.12	0.40	19¼	5½	18
Lucerne ..	3	77.5	0.58	0.12	0.50	39	8	33½
Netchas ..	4–6	85.0	0.36	0.10	0.45	40	11¼	50½
Rape ..	2–4	85.7	0.35	0.12	0.62	23½	8	41½

On sandy soils green manuring helps to consolidate the soil by the formation of humus, which binds the particles together, whilst on clay soils this humus loosens the soil and the carbon dioxide aerates it.

To derive full effects from green manuring sufficient warmth and moisture must be available to allow of rapid decomposition and these two factors are usually to be found throughout the Territory for the greater part of the year. If the land is quite dry, decomposition will not take place and the effect of turning the crop in will be lost.

Many planters do not realize that to get full benefits from a cover crop, it must be periodically turned in to the soil and so more plant food is made available to the crop being grown. In the Solomon Islands, clovers are grown as a cover crop and it is the practice to plough them in every second year, and then allow them to re-establish themselves. This is best done by turning over between alternate rows of palms annually. Thus half the plantation is kept under a cover crop.

Many plantations in this Territory could be considerably improved if such a scheme could be carried out. Admittedly, ploughing is not practicable on many plantations, but good work can be done by regularly turning in cover crops with a hoe.

A quick-growing crop like cowpeas lends itself to the rapid improvement of soil and by establishing a small area and collecting the seed when ripe a large area can soon be established and regular turning in with hoes can be practised.

Most cover crops seen in this Territory appear to have been planted with the idea of controlling grasses and weeds only, and have been allowed to grow unrestricted for years. No thought has been given to the idea of turning them in. This method certainly helps to maintain the nitrogen content of the soil and the decaying vegetable matter improves the soil. Much good plant food has been lost by not practising green manuring. The leaves and stems of all legumes as well as the roots, are rich in nitrogen, and, when it is realized that the removal of nitrogen amounts to 28.73 kg. per ton of copra,(1) it will be realized how necessary it is to maintain an adequate supply of nitrogen in the soil.

One might well quote verbatim the words of Dr. Bryce—(2)

> It would appear that the system of cultivation on coco-nut plantations in the Territory, whereby the soil under the palms is allowed to remain under a permanent covering of grasses, does not provide the most favorable conditions for nitrification, though it may not be unfavorable to the fixation of nitrogen by free living bacteria. The cultivation of the soil by ploughing, harrowing, &c., would, therefore, stimulate nitrification and might depress nitrogen fixation by bacteria. The latter process, however, would probably be more than compensated for by growing a leguminous cover crop on the cultivated soil, and ploughing it in periodically, that is, by a system of green manuring.

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PIG RAISING NOTES.

(By George F. Gee, H.D.A.)

Pigs will not make economical gains or remain in good health unless adequately fed, and it is important that the ration being fed is balanced. By this is meant the relationship of the protein content of the ration to the carbohydrate content, and this ratio differs according to the age and condition of the pig.

As an example, the nutritive ratio for fattening pigs is 1:5 to 1:5.5. This means that for every part of protein (nitrogenous substances) in the ration, there should be 5 or 5.5 parts of *carbohydrates* (starchy and fatty substances).

It has been proved that the feeding of an unbalanced ration may result in paralysis and unthriftiness in young pigs.

There are plenty of feeds available in the tropics for pig feeding, such as maize, kaffir corn, sweet potatoes, &c. These supply the carbohydrate portion of the ration which should be balanced by the addition of protein rich foods as milk, meat meal, peas, peanuts, &c. It seldom occurs that sufficient milk is available to feed to pigs, and this deficiency should be made up by supplying another food which is rich in protein. Meat meal is regarded as the best substitute in Australia, but freight costs may limit the use in the tropics. A ration showing economical returns in Australia consist of 5 lb. wheat or maize, ¼ lb. meal and 1 lb. green feed per day for a pig of 150 lb. live weight. This ration will give maximum gains in weight.

Pigs should be allowed as much grazing as possible and this will reduce the quantity of food to be fed. Any protein deficiency in the ration can also be made up by good leguminous pasture. Local *Desmodiums* and clovers, or cowpeas would be very good in this respect.

A plentiful supply of good clean drinking water is essential for pigs to make economical gains. Running water is good, provided there is no chance of any contamination from higher up the stream. Diseases are spread largely by this means.

Pigs should not be allowed access to stagnant puddle holes as these are also sources of infection, and it is in such places that the larvae of worms are to be found, from whence they infect the pigs.

Adequate housing should also be provided, with wooden floors, as pigs are very susceptible to dampness, chills and draughts, and once a young pig receives a setback it will never make economical gains and it is unwise to attempt to fatten it. It is best killed for home consumption, provided it has not become infected with any contagious disease.

FRANGIPANI.*

Its Beauty and Scent.

(By Walter W. Froggatt.)

All writers who have visited the tropics mention the delicate scented blooms of the frangipani (*Plumieria acutafolia*). It received its scientific name in honour of Charles Plumier, a French priest and botanist, who made three voyages into tropical America and the West Indies during the end of the 17th century. He died at Cadiz, Spain, while fitting out a fourth expedition in 1704. The frangipani was one of the many new plants which he introduced into Europe.

The genus *Plumieria* contains about 50 species of shrubs and small trees. These are confined to those parts of the world which extend from Peru to the West Indies.

The origin of its popular name "frangipani" is more involved. Some claim that it was named after Count Mercuteo Frangipani, an Italian traveller, who visited the West Indies in 1493. The sailors on the brig as they approached the shores of Antigua, noticed a fragrant scent; the Count pointed out the tree, and thus the plant received a name. The Count was a member of a very old Roman family, which received the title "Frangipani" from its benevolence in the distribution of broken bread (frangere, to break; panis, bread), during a great famine. Other botanists disclaim this Italian origin of the name. They give it a French origin and spell it "franchipanicr", which means "coagulated milk", in reference to the quantity of thick white sap which pours out from any broken leaf or branch. It was well established along the shores of Southern Europe in the 16th century and was called a holy flower, because it was used in the decoration of the cathedral altars. It was not until 1790 that it was introduced into England, when Sir Joseph Banks presented some plants which he had obtained from the West Indies to the Royal Botanic Gardens at Kew, London. These plants flowered in the hothouses, and created great interest among the general public.

It is now a most popular plant in the tropical countries of the East. In India, it is used for decorative purposes in the Hindu temples. In the Malay Archipelago, the Malay name is "Banga Orang Sudah Mati", which means "dead men's fingers". The natives plant this shrub over the graves of their relatives, because of its beauty and scent when in flower. But its leafless branches resemble human fingers—hence the name.

The *Plumieria acutafolia* (frangipani) has clusters of great jasmine-shaped flowers. The petals are creamy white, and thick in substance, as if cut from kid leather. The bases of the petals are powdered with deep yellow; and the scent is as exquisite as the flower. The powerful, penetrating perfume known as "Frangipani" is made by perfumers with spices, orris root and musk, and is an imitation of the characteristic scent of the frangipani flower.

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* From *The Sydney Morning Herald.*

ESTATE PRACTICE EXAMINATION.*

19th March, 1938.

(Time allowed 4 hours.)

QUESTIONS AND ANSWERS.

FIELD WORK.

(Opening up New Jungle Areas.)

Questions 1 and 3 compulsory; one other question to be answered as well.

Question 1.

The I.R.R. Committee decided to permit companies to plant up a small percentage of their reserve jungle areas under the new scheme.

Your directors decided to take advantage of this opportunity, and you are instructed to select a suitable area of 100 acres for planting up on the latest methods.

You are told that you must have an original stand of approximately 200 plants per acre, and that the planting material is two basket plants per hole.

The land is hilly, but the ravines will not be difficult to drain.

Your directors request you to send them a rough sketch plan showing the salient features of the area as soon as you can.

Describe *briefly* your procedure from the time you received instructions to proceed with the work until the clearing is planted.

Answer 1.

Upon receipt of instructions to proceed with the selection and planting up of 100 acres of my reserve jungle land, my methods would be as stated below.

The land is hilly, and I would assume that only a light burn would be done, so that as much timber as possible would be left to help arrest erosion.

Details of work to be done—

1. Survey the area, cutting a 6-ft. rentis round the boundaries.

2. Cut 3-ft. inspection rentises every 10 chains across the area from east to west and north to south.

3. Take a field note book, and record as you walk along these rentises any salient features seen, such as swamps, steep ravines, lallang patches, outcrops of rock or laterite, &c., &c.

4. You can now draw your plan and with the aid of a local topo. survey map put in the contours approximately.

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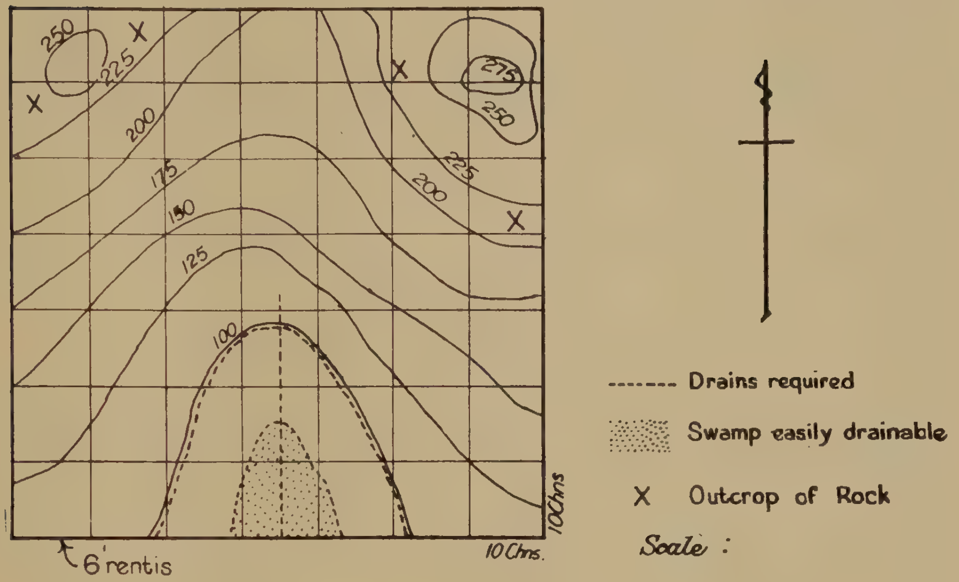
* From *The Planter*, April, 1938, Vol. XIX., No. 4, pages 166–175.

Your plan would then be something like this—



5. Now call in contractors and get tenders for felling, burning and clearing. It should be stipulated that wherever possible felling must be done on the contour.

A time and penalty clause should be inserted to ensure that the schedule is being kept up to date. The contract should stipulate that all trees to be felled should be cut off at 3 feet–6 feet from ground level. A fire-belt of 2 chains should be left round the boundaries where these are adjacent to forest reserve or old rubber; this is later felled and burnt off after the main burn is completed.

6. Whilst felling is in progress, a gang of Javanese drainers should be employed to cut the necessary drains before the trees are felled, and the felling contractor should be warned to see that his coolies do not close up these drains with felled timber.

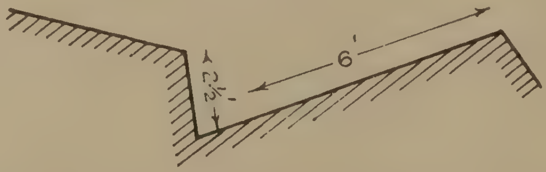
7. About three weeks after felling has been completed, when the weather is suitable, say no rain for four days, a light "scorch burn" should be put over the clearing.

8. Immediately after the burn is over a gang of lining coolies should mark out the planting lines on contour at a spacing of about 20 feet by 10 feet.

9. Coolies, sowing seed of a leguminous creeper or creepers, should follow the liners, and the seed should be established in drills between the planting lines. If sufficient money is available, then phosphate should be applied in the drills prior to planting, at the rate of 1 oz. per running yard. This helps the cover to get established quickly.

10. Chinese felling coolies will now follow the liners, clearing 6-ft. wide strips along the marked contour planting lines. All lying timber will be slewed round to form a bund, to help arrest erosion, and stumps up to 8 inches–10 inches will be eradicated along these lines.

11. Terracing will next be carried out. Terraces 6 feet wide, cut 2½ feet into the solid, will be cut and the spoil thrown forward and be well beaten to form a bund. Terraces should be cut on the wedge form, viz.:—



Stops of uncut earth 2 feet wide can be left between each plant or pair of plants along the contour. These stops help to arrest lateral movement of water along the terraces, and thus prevent large breakages occurring at any weak points.

12. Holes 2 feet by 2 feet by 18 inches will then be cut at each planting point, and these should be left open for some time, and then be filled with debris and good top-soil taken from between the terraces. It should not be necessary to apply fertilizers on this virgin land to begin with.

13. Regular rounds of weeding and lallang patrols will be carried out from the time the burn was completed.

14. Any extra drainage seen to be required can now be done.

15. Germination nurseries to receive good seed collected on the estate will now need to be prepared, with a top layer of fine river sand spread over the soil in the beds. Trenches should also be cut, and baskets filled with good earth be put upright in them to receive the seed after germination.

If the soil on the area is of a friable nature, then a small amount of clay should be placed at the bottom of the basket to save the earth falling out during transport to the field.

The nursery should have attap or palm shades placed over the beds, and these should be gradually removed to accustom the young plants to the strong sunlight. These nurseries should be scattered over the clearing to save transport charges later, and should be near water.

They should be fenced to guard against rats, and if snails are known to be causing trouble on the estate then Meta-Bran pellets should be placed round the nursery, outside the fence.

16. Due to the light burn, your natural covers should regenerate quickly, and these will probably need slashing back to 4 feet before planting takes place.

17. When the basket plants are about 14 days old, they can then be transferred to the planting holes in the field.

Care should be taken to cut the bottom of the baskets to allow the tap root to pass straight down to the bottom of the hole. A surplus of at least 10 per cent. of basket plants should be kept in the nurseries to allow for planting up failures.

In the event of rats causing losses, then rat baits, in which a poison is incorporated, should be put down over the area affected and, if necessary, wire guards should be made to enclose each pair of plants.

18. To stop sun scorch of the soil on the terraces, it has been found useful to plant seed or cuttings of *Desmodium ovalifolium* on them. This plant does not climb, and only needs to be kept back about 1 foot on each side of the rubber plants.

N.B.—If your directors insist on a normal burn, then this will be done three months after felling is completed, and the rest of the programme will remain the same as for an area lightly burnt off. Heavy burns arrest the regeneration of natural covers, and soil wash is often very serious. If, however, an estate is opening up an area adjacent to oil palms, it is often necessary to burn completely, to get rid of rats. The clearing should be fenced with a rat-proof fence if sufficient money is available, and if this is not possible a 4-strand barbed wire fence should be erected to keep out pig and deer.

Question 2.

When burning off a clearing, what precautions do you take to ensure that an even burn results and that no harm comes to the firing coolies?

Answer 2.

When burning off a clearing I should take the following precautions to see that an even burn ensued and that no harm came to the firing coolies:—

1. I should see that the timber was properly dry. For a normal burn the bark of the felled trees should be seen to be splitting.

2. I should wait for a period when I had good dry weather and start the burn after four days of completely dry conditions.

3. I should arrange to have sufficient coolies to have them spaced one coolie per chain across the area to be burnt off.

4. I should muster good coolies, count them and issue each coolie with a bamboo torch filled with kerosene, at the end of which would be placed a sacking wick. Each coolie would be supplied with a box of matches. I should explain carefully the procedure to be adopted, and see that the coolies realized they must keep a straight line, and not try and rush ahead of their neighbours. A Kangany should go with each 15 men.

5. At about 2 p.m. the coolies would be lined up on the far side of the area (towards which the wind was blowing) and be spaced at 1-chain intervals.

I would then station each Kangany in the middle of his party, and tell him that I would be on the left of the line, and that he must not start burning till he heard my whistle.

6. Coolies on hearing the whistle should start the fires and walk towards the wind, burning heaps as they go.

7. On completion of the burn, I should muster all the coolies and count them. I should then leave a few watchmen to see that smouldering logs did not start up new fires that might spread to the reserve jungle areas, or to the old rubber.

8. If my area to be burnt was adjacent to a forest reserve, then I would notify the District Forests Officer and ask him to have some forest guards stationed along his boundary.

Question 3.

You are advised that a series of consignments of expensive isolated garden seeds will be arriving at intervals during the next few weeks.

So that casualties amongst this valuable material may be kept as low as possible, describe how they should be dealt with upon receipt?

Answer 3.

Having been advised that a consignment of valuable isolated garden seed was due to arrive at regular intervals during the next few weeks, I would begin my preparation for their receipt *at once.*

1. I would order sufficient baskets for my requirements, and on their arrival would fill them with good soil and set them upright in trenches in a shaded nursery, or series of nurseries.

2. Germination beds would be prepared, and a top layer of fine sand would be spread over the soil. A fertilizer at the rate of 4 oz. per square yard would be incorporated in the soil.

3. The nurseries would be carefully shaded and well fenced, to keep out rats, &c. Baits for snails, if likely to prove troublesome, would be laid down on arrival of the seed.

4. If the nurseries were to be made in the replanted area, and were near old rubber, I should see that deep isolation trenches were cut, to stop the old rubber roots penetrating the nursery area and competing for the manure.

5. Upon arrival of the seed, which would be received by a competent person, the boxes would be unpacked and the seed established in the beds. The beds would then be lightly watered, and this watering would be continued twice daily whenever there was no rain.

6. The seeds after germination would be transferred to baskets, and these would be watered every day carefully.

7. Shading would be gradually removed to accustom the young plants to the strong sun.

8. Planting would then take place after about 14 days.

N.B.—If I were notified that germinated seed were being sent, then I should prepare baskets only, and plant direct from the boxes to them.

Question 4.

A clearing planted with seedlings to be budded later in the field is backward in growth at six months from planting.

Your agents require immediately as accurate a census as possible of plants likely to prove buddable at one year.

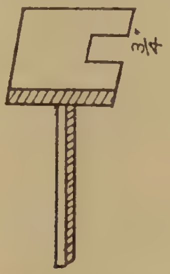
Describe your procedure.

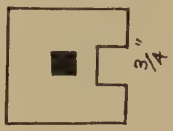
Answer 4.

1. I should carry out a tree-to-tree inspection of all plants on this area.

Any plant found to be affected by root disease would be treated, but would not be included in the final census.

2. I would then have a series of small measuring sticks made, similar to the one shown in the sketch below—





Looking on Top

These measuring sticks are more accurate than a tape, which when it gets wet tends to stretch. The reason I make the cut ¾ inch wide in the top of the measuring stick is because any tree that has a diameter of ¾ inch at six months will be found to be easily buddable by the end of a year. The leg is made 4 inches long, as this is considered by the R.R.I. to be optimum height from the ground for budding operations to be carried out.

The measuring sticks would be issued out to a Conductor and/or Kangany and they would be told to make a careful census, showing only those trees that either fit exactly into the nick, or are larger than it, as being likely to be fit for budding at the end of the year.

REPLANTING.

Question No. 1 compulsory: answer two other questions.

Question 1.

You are instructed by your agents to write to the directors of the R.R.I. and ask for the Institute's advice with regard to clones to be used on an area to be replanted.

What information is required by the R.R.I. from you in order that they may be able to select the clones most suitable for your particular situation?

Answer 1.

The R.R.I. in their *Journal* of October, 1937, Vol. 8, No. 1, page 74, state that they require the following information from estates when a request for advice on clones to be used during replanting is made:—

1. General brief description of the area; lie of the land, &c. Notes on the quality of the rubber trees cut out; age, growth, condition of foliage and bark, previous yields. Notes on history of previous cultivation.

2. Soil profile pits should be dug in representative parts of the area. Pits should be 6 feet deep by 3 feet square, and one side of the pit should be kept free of excavated soil.

3. Description of the soil profiles should be given on the following lines:—

(*a*) Position of pit, i.e., top, side or bottom of hill.

(*b*) Colour of soil with changes at different levels and the depths at which changes occur.

(*c*) Depth of organic colouring ("humus") of surface soil.

(*d*) Notes on texture and compactness of soil at different levels.

(*e*) Presence of stones, laterite (shape and size of lateritic masses is of interest), quartz fragments or other types of stones.

(*f*) Depth of water-table, if visible.

4. Average rainfall for the district should be given. The occurrence of heavy storms likely to result in damage to trees should also be noted, particularly if the area is in an exposed situation.

5. If young budded areas have been established on other parts of the estate on soil of similar type to that in the replanted area, notes on the appearance and vigour of different clones will be of great interest and value.

Question 2.

You are told by your visiting agent to put down ½ lb. of artificial fertilizer per hole during your replanting operations.

When would you apply the manure and in what position is it placed in the planting holes?

Answer 2.

Having been told by my visiting agent to put down ½ lb. of artificial fertilizer in the planting holes during replanting operations, I should incorporate this in the good soil that is placed in the top half of the planting hole, about 5 days before planting actually takes place. This point I consider especially important where replanting was being done on a friable soil.

If the manure is put at the bottom of the planting hole there will be a tendency for it to leech away before the rubber gets full benefit from it.

Question 3.

Why is it safer to use hand-pollinated and/or isolated garden seed when replanting, rather than to use so-called clonal seed collected from an area of mixed buddings?

Answer 3.

I should consider it safer to use hand-pollinated and/or isolated garden seed when replanting, rather than so-called clonal seed collected from an area of mixed buddings, for the following reasons:—

1. The hand-pollinated seed will have been made by artificial pollination from trees of proved quality, and the chances of variation amongst the resultant crosses will be considerably less than from seed collected from a mixed clonal area. Hand-pollinated seed is not usually available in commercial quantities.

2. Seeds from an isolation garden are also more desirable, as they, although they have crossed naturally, are presumed to be free from the risk of contamination from seedling pollen or pollen from a mixed area in which a number of poor yielders are situated.

3. If, however, I was satisfied, and the seller would guarantee that in his area of mixed clones he had a predominant stand of a strong mother tree such as Avros. 157, then I would not object to planting out this seed.

In the event of this guarantee not being available, I would prefer, as stated above, to use hand-pollinated or isolation garden seed.

Question 4.

Your clearing is hilly and has had to be terraced, and natural covers are trying to establish between terraces.

Signs of erosion, however, are to be seen, and your visiting agent recommends that low leguminous covers should be established and be allowed to climb over the natural covers, thus helping to arrest erosion.

Describe your method of procedure for establishing these low covers.

Answer 4.

My visiting agent having noticed that, despite the fact that natural covers are trying to establish between terraces, there are signs of erosion taking place, I would adopt the following precautionary measures:—

1. I would purchase seed of *Centrosema pubescens,* allowing for 8 lb. per acre.

2. In a small drill just below the terraces, I should apply a fertilizer, probably rock phosphate, at the rate of 1 oz. per running yard. The earth would be lightly scuffled over the fertilizer after it had been applied.

3. I would then plant my *Centrosema* seed at the rate of about 5 oz. per yard in this drill, and would take care to see that weeds, &c., were regularly eradicated and the young cover given a chance to establish and climb over the natural covers. Some people prefer to soak this seed overnight before planting; others consider that this is unnecessary.

GENERAL UPKEEP OF A PLANTED AREA.

Questions 1 and 2 compulsory: two other questions to be answered.

Question 1.

Your clearing has a healthy cover of *Pueraria, Calopogonium* and *Centrosema* established over it, and despite the fact that you are keeping 4-ft. diameter rings around the plants free of covers, you notice that the rubber is retarded.

Describe a method of cultivation that should help improve the growth, but does not necessitate fertilizers being applied.

Answer 1.

The retardation seen in the rubber is probably due to competition for moisture and plant food from the cover crops.

Three methods would appear to present themselves for consideration—

1. In the event of my agents instructing me to carry out the work as cheaply as possible then I should simply pull back the covers, leaving 6-ft.–8-ft. rings free round the plants.

2. If, however, the question of expense did not arise, I would prefer to cut and roll back the covers, leaving a 6-ft. ring free round the plants. The cut-off covers would then be buried in a trench cut between each pair of plants. This would have a beneficial effect on the rubber and would take the place of an artificial fertilizer.

3. Another method which is not as expensive as the one above is to pull the covers back so that 6-ft.–8-ft. rings are kept free round the plants. The rolled-back cover is then cut and spread over the exposed soil round the rubber plants. This helps to keep the soil cool and also keeps weeding costs down. A combination of methods 2 and 3 would be good.

Question 2.

On your clearing you have a stand of mixed bushy *leguminous* covers. These covers require slashing.

At what height do you recommend that these covers be slashed and during which periods of the year would you carry out slashing?

Answer 2.

I would slash my covers back to 4 feet during or just prior to the main wet seasons in March–April, October–December.

The cover will be flowering about this time and the nitrogen content in the leaves will be heavy. I would not slash my covers back during the dry season as the covers will not rot away quickly then, and there is also the danger of fire occurring. Further, the shade from the bushes is needed during the hot dry spells to keep the soil cool.

Question 3.

On your clearing, upon which the low leguminous creeping covers are establishing well and in which 4-ft. rings are kept free of covers round the plants, monthly weeding is done.

Describe the correct procedure to be carried out by your weeders in this area.

Answer 3.

My weeders on their monthly rounds would be given the following instructions:—

1. They would be told to eradicate all weeds seen in the rings or along the strips and in the covers between the rows.

2. They would be instructed to keep a careful look out for lallang and to eradicate this completely when seen. The eradicated lallang to be placed in "kutty sacks" and be brought back to the lines after work where it would be burnt off.

3. If hand-weeding is necessitated the weeders would be told to see that they knocked all the earth off the roots of the weeds as they pull them up and lay them on the cover outside the rings.

4. If Tajah weeding or forking is to be done weeders should weed the circles, one month towards the trees from the outer edge of the rings, and the next month away from the trees. This will prevent the formation of a hollow or a mound round the collars of the young plants.

Question 4.

Scale insects attack one of your nurseries, and you are instructed to get rid of these pests as quickly as possible.

Describe your method of procedure.

Answer 4.

Finding that scale bugs have attacked my nursery, I should issue the coolies with tins containing a soft soap-kerosene emulsion, or a tar-acid emulsion as is used for mouldy rot, and would instruct them to wipe the affected stems and branches of the plants in the nursery with a cloth dipped in one or other of these disinfectants.

Question 5.

On the area that you have to replant, the soil is of a friable nature.

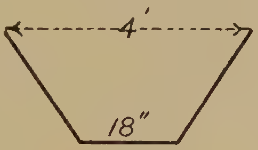
You are instructed to put in a drainage system prior to planting commencing.

What precautions would you take when cutting your drains to ensure that you did not experience considerable trouble in the future from slipping occurring on the banks of the drains?

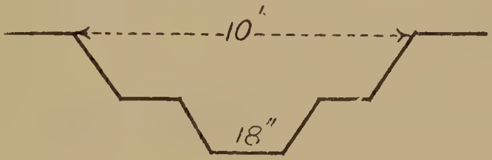
Answer 5.

Having been instructed to put in a drainage system prior to planting commencing in an area in which the soil is very friable, I would take the following precautions to ensure that trouble from bank slips was reduced to a minimum.

1. I would cut the drains, if small, with good sloping sides, say 4 feet at the top and 18 inches at the bottom, viz.:—



2. For the main outlet drains the sides would be cut with steps, viz.:—



3. The water in the bottom of the drain, especially during the wet weather, will tend to undercut the banks, and to prevent this I would establish a creeping grass such as *Axonopus compressus* from 6 inches above water level for 2 feet up the banks on either side.

I would not plant the grass right down to the water level, near coolie lines, &c., as this might make breeding places for *anopheline larvae* to collect. In some areas this undercutting of the banks after rains may necessitate revetting being done.

Question 6.

Your stand of young bud-grafts is 150 to the acre at four years of age.

Your agents instruct you to proceed with a thinning-out programme so that your stand will be reduced to 130 trees per acre.

Describe your method of procedure.

Answer 6.

It is generally accepted that within a clone bud-grafts can be thinned out on size and appearance.

Weak trees and those affected by root disease, white ants and wind damage will, therefore, be eradicated first.

In the event of this not being sufficient to bring the stand down to the required number, trees of small girth are next taken out.

It is not necessary to carry out test tapping unless the clones planted on your area are improved ones.

In the event of your having on your area a clone which is known to be a higher yielder than the others, it may be possible to keep a higher stand of this clone provided due attention is paid to spacing.

CONTROL OF PESTS AND DISEASES.

Answer two questions.

Question 1.

Describe the method of treatment recommended by the R.R.I. for the treatment of pink disease.

What precautions is it necessary to take to ensure that the disinfectant is correctly applied?

Answer 1.

The method of treatment recommended for pink disease by the R.R.I. is as follows:—

1. On trees with mature bark attacked by this disease the affected parts and also 6 inches of good bark (i.e. that in which latex can be seen to flow if scraped) above and below should be painted with asphaltum-kerosene mixture. This is made up by heating together 10 lb. of asphaltum D.X. and 1 gallon of kerosene or solar oil, and when cool adding one pint of a recommended wood preservative, such as Brunolinum, Noxo, &c.

2. On trees where the bark is still green it is better to paint with one of the water-miscible disinfectants that are used for mouldy rot, instead of the asphaltum-kerosene mixture (Killgerm Agrisol, Izal, &c.) at proportions recommended, i.e., 5 per cent.–10 per cent.

3. Dead or badly diseased branches should be painted first, and then be cut off and burnt. Painting can be done at any time, but it is best done when the trees are fairly dry. Cutting off of dead and badly diseased branches should be done in the dry weather and those affected parts should be burnt immediately.

4. It is important to remember that when using the asphaltum-kerosene mixture it must not be applied hot, and must be spread evenly over the whole affected part and not on one side of the branch only.

Question 2.

Describe briefly the treatment recommended by the R.R.I. for root disease control in young rubber.

Answer 2.

The method of control for root diseases in young rubber and the treatment employed as recommended by the R.R.I. of Malaya, is as follows:—

A careful tree-to-tree inspection of every plant in the clearing can be carried out quite inexpensively. The ground at the collar of each tree should be opened up to show about 6 inches of the lateral and tap roots.

Digging should be done with a pointed hard-wood stick, and changkols should *not* on any account be employed. The coolies should be instructed to try and keep root damage during opening to a minimum. The exposed parts of all the roots seen should then be examined for signs of root disease. If no rhizomorphs are found on the roots the holes should then be filled in and the soil trodden down firmly.

Where a plant is seen to be infected, the hole is left opened and treatment is later carried out as follows:—

1. Dig out until all infected roots are exposed. This will probably lead to the infected jungle root or old rubber root which has caused the infection.

2. Remove the source of the infection and burn it. If any other old rubber roots or stumps adjacent to the infected plants are seen they should be inspected and, if diseased, eradicated and burnt.

3. Cut off and burn all parts of the roots of the rubber tree which have been penetrated by the disease fungus.

4. Wash all other roots on which there are rhizomorphs, but which have not yet been penetrated (i.e. if they still contain latex), with a solution of 2 per cent. copper sulphate in water. While washing rub hard enough to remove the rhizomorphs, but do not rub too hard, for the copper sulphate will burn the bark of the roots.

5. Trees which are dead or seriously infected should be removed and burnt together with the diseased jungle or rubber roots which have caused the infection.

6. Trees which have been infected but have been treated should be marked with a paint band. If this is done it is easy to make a "kira" of the number of cases of infection and to plot out on a chart the infected areas.

7. Regular round of inspection should be carried out twice a year and again all infected trees should be marked. It is thus hoped that by the fourth or fifth year, the marked trees will show up the areas which are still potential danger spots and work can be concentrated on these areas to try and find the disease focus and remove it and opening up and inspection of healthy trees may prove unnecessary.

8. On replanted areas where there has been no history of disease in the past, and no disease was found when felling was carried out, an annual root disease inspection should suffice.

Question 3.

Root *Ustulina* is prevalent on your estate.

What precautions would you take to ensure that there was no recurrence of this disease on your trees?

Answer 3.

Finding that root *Ustulina* is prevalent on my estate I should institute a careful round of inspection and treatment.

Seriously affected trees would be eradicated and burnt, and those lightly affected would have the infected portion at the foot of the tree or on the root chiselled out until no more signs of the disease were to be seen. The cut surfaces would then be protected with a suitable wound dressing such as asphaltum-kerosene mixture or tar.

As the disease is carried by wind-blown spores I should see that all earth scrap latex round the base of the trees was carefully removed now and in the future and I would instruct the coolies to make as few wounds as possible whilst removing this earth scrap, any wounds made being treated immediately. These precautions should be sufficient to rid the estate of this trouble, as the spores can only gain entry to a tree through a wound surface.

FACTORY.

Answer any two questions.

Question 1.

Give the reason for copper contamination in sheet and how the danger of extraneous copper may be overcome.

Answer 1.

Danger from copper contamination in sheet can be overcome by eliminating all articles containing copper in the factory. Brass sieves should be scrapped, monel-metal ones should be purchased and be used. These monel-metal sieves and strainers are more expensive than the brass ones but last considerably longer and therefore repay the original outlay.

Copper contamination may also take place from worn bearings on the sheeting battery. When this occurs, the minute particles of copper reach the sheet along the rolls, on a thin film of oil. Care should, therefore, be taken to see that over-oiling is not done and that the rollers are cleaned regularly.

Question 2.

How do you proceed when receiving latex at the factory if you desire to obtain sheets standardized at 1½ lb. dry rubber content?

Answer 2.

To standardize latex to 1½ lb. D.R.C. the following method can be adopted.

Pour the latex on arrival at the factory through strainers into the Shanghai jars or bulking tanks. Then take a tin vessel and put into it one part of latex and two parts of water by volume; then take your metrolac and get the reading of the mixed latex and water. Multiply this reading by three which will give you the D.R.C. of the field latex.

Provided that the D.R.C. of your field latex is not less than 3 lb. per gallon fill your tanks half full of water and put the latex from the Shanghai jars or bulkers into your tanks. Stir well and take a second reading.

If the reading does not show 1½ lb. D.R.C. add more water and stir well and take more readings with the metrolac until the latex reaches the required standardization of 1½ lb.

In the event of the original reading of your field latex being less than 3 lb. D.R.C. the tanks should then only be quarter filled with water before the latex is added.

Formic acid is then added to the latex in the tanks at the rate of 7½ oz. per gallon of standardized latex. The latex in the tanks is then well stirred and all froth carefully skimmed off. The tank slats are then put in and the latex is left in the tanks overnight. Milling is done next morning.

Question 3.

Why is *para-nitrophenol* used in the manufacture of sheet rubber and how is it applied to latex in the raw state and for soaking purposes?

Answer 3.

Para-nitrophenol is used in the manufacture of sheet rubber to prevent the development of "mould and rust".

For adding to latex a stock solution is made by dissolving 1 lb. of the commercial solid in 10 gallons of water. One gallon of the stock solution is then added to 60 gallons of standardized latex before the coagulent is added. For soaking sheet a dilute solution of 5 gallons of stock solution is made with 50 gallons of water and the sheets are passed into this as they leave the marking machine. Fifty-five gallons of this solution are sufficient for 1,000 lb. of sheet per day. The solution should be renewed daily, and the stock solution should be prepared sometime before it is needed, as *para-nitrophenol* is not readily soluble in water.

Question 4.

Your smoke house is burnt down and you are told to erect immediately a temporary smoke house so that you may carry on until a permanent smoke house has been built.

State what type and capacity you assume the burnt-down smoke house to have been, and give approximate cost of the temporary building and its capacity.

Answer 4.

My smoke house, which deals with a crop of 2,800 lb. per day, gets burnt down, and I have to make preparations to continue smoking in temporary conditions. I would immediately call in a Chinese or Malay contractor and get him to put up eight temporary attap and bamboo smoke houses as recommended by the R.R.I.

These buildings, 12 feet square and 11 feet to the eaves, would consist of outer walls of split bamboo fixed on to hardwood posts. The inner walls and ceilings would then be lined with brown paper stuck on to the bamboo with sodium silicate or tapioca flour paste. Roofs of attap would cover the inclined ceilings. Ventilation holes 1 foot x 9 inches would be cut near ground on three sides and two further ventilation holes would be cut in the ceilings. Two windows and a door would be made and be fixed. In each building a firebox from half (60 gallons) an old oil drum would be placed in the centre of each chamber with a corrugated iron baffle plate hung over it. Uprights with racks would be put in across the width of the building on both sides of the fireboxes. The uprights adjacent to the fireboxes would be enclosed with corrugated iron sheets to prevent them from catching fire. Chambers of these dimensions will hold 1,800 lb. of sheet rubber and provided the sheet is of a thickness of from $\frac{1}{8}$ inch to $^{1}/_{10}$ inch will dry the sheet in five days. Thus from each chamber one gets 350 lb. dry sheet per day making a total of 2,800 lb. from the eight smoke houses.

The cost of each of these buildings is at present approximately 70s. and therefore the total expenditure on the eight buildings will be 560s.

It is possible to get an insurance policy for European estates for sheet rubber smoked under these conditions.

Question 5.

Give reasons and remedies for the following defects in sheet:—

(i) Dark patches.
(ii) Greasy surface.
(iii) Pitted surface.

Answer 5.

Dark patches.—Irregularly shaped dark and light coloured patches often occur on sheets. These are caused by surface oxidation on the sheet, especially when coagulation is done in pans as the latex tends when coagulated to rise above the surface of the water.

Another cause is soaking sheets in water after rolling and allowing them to come into irregular contact with each other during this operation.

1. After coagulation the pans or tanks should be flooded with water to prevent the upper surfaces coming in contact with the air. The use of sodium sulphite in the latex will help to reduce this tendency to oxidation.

2. Sheets which are not spread with water during rolling and which are subsequently soaked in water should be placed singly in the soaking tanks in order that they may not become massed together.

3. When sheets are allowed to soak in water or have to be piled in a wet condition, they should be passed through a solution containing 1 lb. of *para-nitrophenol* in 100 gallons of water.

Greasy Surface.—1. Insufficient washing of the coagulum on the machine rolls. A water spray should be used on sheet machines.

2. The use of too strong a coagulant or too much sodium sulphite.

3. The use of firewood giving an excess of smoke products.

Moulds.—1. Soak the freshly-machined sheet in water if no water spray is available on the rolls.

2. Soak the freshly-machined sheet in a solution of 1 lb. *para-nitrophenol* in 100 gallons of water.

3. More efficient ventilation during the early stages of drying and smoking.

Pitted Surfaces.—Pitted surfaces usually take the form of small pockets or depressions on the surface of the sheet.

1. This is generally caused by careless skimming so that the surface bubbles remain, which are broken when the sheet is machined.

2. The division boards in the tanks may become sour owing to the growth of micro-organisms which set up fermentation when they come in contact with the slats.

3. A lack of water on the machine rolls so that the water only gets on the upper surface of the sheet leaving the lower roller dry. This may cause pitting of the surface of the sheet in contact with the lower roller.

Remedies are—

1. Proper skimming and removal of all froth.

2. Periodic skimming and washing of coagulation tank slats in a dilute solution of formalin and/or *para-nitrophenol* solution, and subsequent exposure of the slats to sunlight.

3. Solution of $\frac{1}{2}$ lb. of *para-nitrophenol* to 10 gallons of water should be used for soaking boards and tanks.

4. More water on the rollers using an efficient spray so that both rollers get a fair proportion of water.

SANITATION AND ANTI-MALARIAL.

Answer both questions.

Question 1.

A wave of malaria among the labour force follows replanting of an area near the lines.

Describe—

(i) How would you ascertain whether the malaria does in fact emanate from the replanted area?

(ii) What precautions should have been taken at the time of replanting to obviate this danger?

(iii) What precautions must now be taken to render the areas safe?

Answer 1.

1. (*a*) I should take a muster of all coolies having fever or showing palpable spleens. I would try and trace out what these coolies had been doing for the past 10–12 days and see if the fever had been contracted on the estate or outside it.

(*b*) I would make the dresser do an anti-malarial survey of the replanted area and see if any anopheline larvae were to be found in planting holes, ravines or swamps. I should then state my conclusions to the V.M.O., and ask for his advice as to treatment to be adopted.

2. (*a*) All ravines, hollows and streams should have been carefully drained prior to falling being done, and care should have been taken to see that felled trees, &c., did not close up these drains.

(*b*) All planting holes likely to hold water should have been filled up as soon as possible.

(*c*) Regular oiling rounds over a mile radius should have been carried out.

3. (*a*) Labour force should be mustered and all coolies having fever or palpable spleens be put on treatment.

(*b*) Drainage as required to be put in hand at once and all holes holding water to be filled up.

(*c*) Regular oiling rounds instituted and close supervision be given to this work by the dresser.

(*d*) V.M.O. to be asked to inspect on his next visit and to approve methods used or to make suggestions for further improvements.

Question 2.

A coolie on your estate returns from the fields complaining that he has got fever.

What procedure do you adopt?

Answer 2.

1. Dresser should take two blood slides (one to be sent to V.M.O. for inspection).

2. Dresser to examine for spleen and take haemoglobin test.

3. If slide proves positive, put to bed and give 10 grains of aspirin. Ring up V.M.O. and ask for details of treatment to be carried out. If estate hospital available send to the hospital.

4. If no hospital available, and V.M.O. approves, give treatment on estate and, on completion of course, put coolie on an iron tonic course.

ECONOMIC DEVELOPMENT OF NEW GUINEA.*

An interesting paper by Dr. W. C. Klein, Secretary of the Netherlands New Guinea, published in the *Asiatic Review* (1937, 33, 566-580), compares the development of the resources and trade of Dutch New Guinea with that part of New Guinea which is controlled by Australia (Papua and the Mandated Territory). By means of statistics of exports he shows how in the exploitation of forest produce, such as gum copal, timber, rattans, nutmegs and mace, Dutch New Guinea is ahead of the Australian regions. This the author attributes partly to the skill of the Chinese trade in the former country in inducing the natives to bring certain of these products to the trading stations, whereas in Papua the traders are wholly, and in the Territory of New Guinea mainly, Europeans. As regards gum copal and nutmegs the trees are practically confined to the Dutch territory.

In the case of plantation products, on the other hand, there is a marked superiority in quantity and value on the Australian side. The most important of these is copra, which in the Mandated Territory and in Papua is produced mainly on European-managed plantations, whilst in the Dutch territory the bulk is native copra. The success of the industry in Australian New Guinea is considered to be due to a large extent to the more reliable labour supply, the better shipping facilities, and the proximity of the Australian market. The system of marketing is also better on the Australian side, being more in the hands of large firms.

Surprise is expressed that, in spite of the export bounty, the scientific work of the local Agricultural Department and the favorable soil conditions, the cocoa industry of the Territory of New Guinea does not make greater progress, especially in view of Australia's large imports of this commodity from West Africa and the West Indies. It is suggested that this may be due to the native kanakas being less intelligent than the Gold Coast natives, a fact which the author says accounts for the failure of the few cocoa experiments which have been made on the Dutch side.

Papua is the only territory of New Guinea which is exporting rubber.

Another product confined to the Australian side is desiccated coco-nut, which is now being made in both Papua and the Mandated Territory to supply the Australian market.

Metals also have hitherto only been produced in Australian territory, viz., copper in Papua and gold in both Papua and the Mandated Territory, especially the latter. A big prospecting campaign for gold has, however, been started in Dutch New Guinea.

A consideration of the value of the total volume of trade (exports and imports) shows that whereas in the Dutch territory the increase during the 30-year period commencing 1905 amounted to 70 per cent., in Papua it rose 300 per cent., whilst in the Mandated Territory the increase was no less than

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* From *Bulletin of the Imperial Institute*, Vol. XXXV., No. 3 (July–September, 1937).

1,600 per cent. In the early days the exports from Dutch New Guinea exceeded the imports, whereas on the Australian side the reverse was the case. That is to say, the Dutch were taking out all they could from their territory, whilst in the remainder of the country money was being put in for its development. This sounder policy is now reaping its reward for the Australians, and it is only in the last few years that the Dutch have been spending increasing sums of money on development, largely in connexion with the exploration of gold already mentioned, and also in a search for oil.

SOILS.

Classification.—Soils are formed by the decomposition of mineral, animal and vegetable matter. They may be designated as sedentary or transported. Sedentary soils are those which remain near their source of formation, while transported soils have been carried by some geological agency from the place where they were first formed to some other. Soil as far as its composition and properties are concerned is extremely variable. The principal constituents of any soil, however, whatever its source, are nearly always silica, with varying amounts of alumina, oxides of iron, lime, magnesia, and the alkalies. A small amount of organic matter is also usually present. Soils are generally classified as gravel, sand, clay, loam, marl, peat and muck.

Gravel consists of small pieces of rock, worn smooth by abrasive action, mixed with sands and clays in varying proportions. Gravels occur throughout the United States and Canada in those districts which were at one time covered with the glacier. Gravel should contain enough binding material, mixed with the stone particles, to bind the whole into a solid mass. Clay is the most common form of binder found in gravel in its natural state. If present in too large quantities, however, it is detrimental. If gravel does not have sufficient binding material this can be remedied by adding some cementing material such as clay, shale, marl, loam, or stone screenings. Some gravels contain so much earthy material that it is necessary to screen them before they are suitable for road-making purposes. An indication of the binding qualities for pit gravel may be obtained by noticing the gravel in the pit. If the bank faces are vertical and the gravel breaks off into chunks, good binding qualities may be expected. River gravel generally contains less clay and more silica than the pit gravel of the same locality. Soil classified as hardpan may mean either a very compact clay, or a gravel which is cemented with clay or an iron oxide.

Sand is largely the result of breaking-down of sandstone rocks and a sandy soil so-called probably contains over 80 per cent. of pure sand. A sandy soil is hard to compact, and possesses little binding power unless wet or mixed with some cementing material such as clay. Quicksand is sand saturated with water, and possesses no stability.

Clay results from the decomposition of feldspar, oligoclase and micaeous rocks. A clayey soil might be termed such when containing at least 60 per cent. of clay. Clay when wet will swell and puddle with water, becoming very plastic. When mixed in the proper proportions with sand or gravel, it makes a very satisfactory road material in localities where stone is unobtainable. Clays used for fire clays in the manufacture of brick, besides being plastic, must possess certain refractory qualities which enable them to withstand long periods of heat at high temperatures without fusing. Shales are chemically the same composition as clays, but they have a laminated structure, and are similar in appearance to slates. Shales, however, will rapidly disintegrate on exposure to the atmosphere. In the south-western States a clay of which mud bricks might be made is called "adobe".

Loams may be any soil between sand and clay. They contain more or less of each of these two materials. They may be classified as heavy clay loams, clay loams, sandy loams, and light sandy loams, depending upon the quantity of the sand or clay content. In the Middle West a black loam which contains so much clay as to be sticky when wet is known as "gumbo".

Marl is a term which applies to all calcareous clays containing as a minimum 15 per cent. of carbonate of lime, and as a maximum 75 per cent. of clay.

Peat and *muck* are generally distinguished from other soils by the presence of humus or vegetable matter. They are formed by the decomposition of vegetable matter under water, and are undesirable materials for road-building.

HOUSEHOLD HINTS.

You can prevent olive oil from becoming rancid by dropping a lump of sugar in it. The sugar will not affect the taste of the oil.

* * * *

Salt is one of the most useful of household staples. Cracked eggs can be boiled without the insides oozing out by simply adding a teaspoonful of salt to the water. Sinks and drains can be kept free from grease and disagreeable odours by pouring a strong solution of salt and hot water through them once a week.

* * * *

To sharpen scissors, open them and gently draw the cutting edges back and forth on a piece of glass or the neck of a bottle as though you were going to cut it off.

* * * *

If soup is too salty, slice a raw potato and drop it in the soup. Bring the whole thing to a boil, then remove the potato and you will find that saltiness is gone.

* * * *

To keep your ice box sweet and fresh, put a small piece of charcoal in the back of it. The charcoal will absorb the various odours that accumulate in even the cleanest ice box.

* * * *

When it comes to cleaning knives—especially carving knives—an ordinary large size cork is better than a dish-rag. Put a little soap or scouring powder on the cork and rub it over the knife. To remove the odour of raw onions or garlic from knives, draw them through a raw potato.

* * * *

A bit of vinegar added to the water in which poached eggs are cooked will keep the whites of the eggs from spreading.

* * * *

To drive a nail into plaster without crumbling the plaster, dip the end of the nail first in melted wax or soap.

* * * *

If you have a vegetable or flower garden, don't throw away egg shells. Put them in a bucket, jar or other container, and fill the container with water. After it has stood for a day or so, the solution becomes an excellent fertilizer with which to sprinkle your garden.

* * * *

To iron over buttons, place the garment button-side down on the ironing board, and put some soft material such as a turkish towel beneath it. The buttons will leave their impression on the towel instead of on the garment you are ironing.

SHIP MEASUREMENT.

Under deck tonnage is a measure of the internal space between the top of the ceiling or double bottom in the hold and the under surface of the tonnage deck. The unit of measurement is a ton of 100 cubic feet.

Gross tonnage is a measure of the total internal volume of the ship, and is equal to the under deck tonnage plus the tonnage of all enclosed spaces above the tonnage deck.

Net tonnage is the residual tonnage after the various allowances for propelling power, crew, spaces and navigation spaces have been deducted from the gross tonnage.

Displacement tonnage is the total quantity of water displaced by the vessel when floating at her load draught.

Deadweight tonnage is the number of tons (of 2,240 lb.) of cargo, stores, &c., that a vessel is capable of carrying when floating at her load draught.

Load water-line is the water-line corresponding to the maximum draught to which a vessel is permitted to load, either by the freeboard regulations, the conditions of classification, or the conditions of service.

Draught is the distance from the lowest part of the keel to the water-line at which the vessel is floating.

Load draught is the distance from the lowest part of the keel to the load water-line as defined above.

Freeboard is the distance from the upper (or freeboard) deck to the centre of the disc which is marked on the vessel's sides and which indicates the position of the load water-line in summer.

TIME ON BOARD SHIP.

The day of 24 hours is divided into seven watches. The day commences at noon and is thus divided—

Noon to 4 p.m.	afternoon watch
4 p.m. to 6 p.m.	first dog watch
6 p.m. to 8 p.m.	last or second dog watch
8 p.m. to midnight	first watch
Midnight to 4 a.m.	middle watch
4 a.m. to 8 a.m.	morning watch
8 a.m. to noon	forenoon watch

The purpose of the two dog watches is to make an odd number of watches in the 24 hours, thus giving the men different watches each day.

Time is kept on board ship by striking a bell every half hour, the rule being—One stroke of the bell at half-past four, half-past eight, and half-past twelve, one more stroke being added for each half-hour until eight strokes of the bell or eight bells are reached at four, eight and twelve. The dog watches are different, 6.30 p.m. being one bell, 7 p.m. two bells, and 7.30 p.m. three bells, but 8 o'clock is always eight bells.

MENSURATION OF SURFACES AND SOLIDS.

The circumference of a circle = diameter × 22/7 (or 3.1416); area of circle = square of the diameter × 0.7854.

Area of sector of circle = length of arc × $\frac{1}{2}$ radius.

Area of segment of circle = area of sector less area of triangle.

Area of a square, rhombus or rhomboid = base × height.

Area of a triangle = $\frac{1}{2}$ base × perpendicular height.

Area of equilateral triangle = square of side × 0.433.

Area of any right-lined figure of four or more unequal sides is found by dividing it into triangles, finding area of each and adding together.

Area of a parabola = base × height × $\frac{2}{3}$.

Area of an ellipse = long axis × short axis × 0.7854.

Volume of a pyramid = area of base × one-third of height.

Volume of a sphere = cube of diameter × 0.5236.

RAINFALL.

The depth of rainfall in inches, multiplied by 3,630, equals number of cubic feet per square acre; multiplied by 22,688, equals number of gallons per square acre.

Thus—

Inches.		Cubic feet per acre.		Gallons per acre.		Tons per acre.
1	=	3,630	=	22,688	=	101.3
2	=	7,260	=	45,376	=	202.6
3	=	10,890	=	68,064	=	303.9
5	=	18,150	=	113,440	=	506.5

1 cubic foot of water = $6\frac{1}{4}$ gallons = $62\frac{1}{2}$ lb. = 1,000 oz. = about $\frac{3}{4}$ bushel. 40 × 10 × 10 feet (4,000 cubic feet) = 25,000 gallons. 1 cubic inch of water = $\frac{3}{5}$ oz. by weight. 1 pint of water = 20 oz. by weight. 1 gallon of water = 10 lb. by weight. 1 ton of water = 224 gallons. 1 oz. of water = 1 oz. by weight. 1 lb. of water measures $27\frac{3}{4}$ cubic inches. 1 ordinary tumbler holds 10 liquid ounces. 1 tablespoon holds $\frac{1}{2}$ liquid ounce. 1 teaspoon holds 1 liquid drachm or 60 drops. 4 teaspoonsful = 1 liquid ounce.

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SOME INVESTIGATIONS ON COCO-NUT DISEASES ASSOCIATED WITH SOIL CONDITIONS IN NEW GUINEA.

(*Continued.*)

R. E. P. Dwyer, B.Sc.Agr., Economic Botanist.

In the previous instalment of this article (*New Guinea Agricultural Gazette*, Volume 5, No. 3, December, 1939) an account of some investigations and observations on occurrences of physiological disorders of coco-nut palms was presented. Particular attention was paid to investigations of maturation wilts of young coco-nut palms recorded from various parts of the Territory of New Guinea.

A further contribution on the subject is now presented. Some physiological derangements of mature coco-nut palms, particularly from those plantations situated on the deltaic and estuarine deposits on certain areas of the New Guinea mainland, are described, together with the contributory causes. These occurrences are compared with similar diseases recorded from other countries. The chemical and physiological changes, especially as regards moisture requirements and potash movements, which occur on coco-nut palms at various stages of growth are indicated and discussed in relation to the diseases described. An account of several other diseases and derangements of coco-nut palms, associated with unfavorable soil, moisture and nutritional relationships, are also discussed. The employment of proper cultural methods in the control of coco-nut diseases, especially those of physiological origin, is indicated.

CHEMICAL AND PHYSIOLOGICAL CHANGES IN THE COCO-NUT PALM RELATED TO MATURITY.

According to Sampson[(24)] who furnishes the most complete analyses on the coco-nut from this point of view:—

> In the case of *nitrogen* the heaviest demands are made on the resources of the tree quite late in the development of the fruit, i.e., within the last six weeks or eight months. Nearly 75 per cent. of the nitrogen removed from the tree when the ripe fruit is harvested is to be found in the meat of the nut. Analysis shows as regards *potash* that the demand for this commences early in the development of the fruit. The quantity of potash in the meat seems to be greatest at the time when the meat is being laid down after which it seems to be reduced, when no longer required for this work. The supply of potash seems to be readily forthcoming when it is required. It is probable that this being a more soluble salt than most other plant foods, there is much more elasticity in the supply, it being taken away from other parts of the plant, resulting possibly in the retardation of growth for the time being, and brought to where its presence is essential. (The significance of this in relation to a maturation wilt is self-evident, when the potash is transferred from the fronds to the developing fruits.) Potash is required in large quantities by any rapidly growing part of the palm. Such growing parts are always present. The bud or "cabbage" is continually forming new leaves and these leaves are all the time expanding. In the axis of each leaf a flowering branch is normally formed, and this in its turn has to grow very rapidly until the flowers expand. Even after this it continues to grow rapidly as the fruit which it carries are swelling and the meat within the fruit is forming. All these places show a concentration of potash. In the leaves also large quantities of potash are required especially in the young plant. The plant, however, is able to remove a large part of the potash from any working part of the plant, as this gets past work. Thus in the young tree not yet in bearing, it is seen that there is 41 per centum of potash in the ash of the tender leaf which is growing. In the fully developed green or working leaf there is only 18 per centum.

It has been shown by numerous investigators with temperate fruits and other crops, that the proportions of carbohydrates (sugars, starch and cellulose) to nitrogen (i.e. the carbohydrates/nitrogen ratio) greatly changes at the time of blossoming and fruit setting. How far this is true of coco-nuts does not appear to have been determined, but the indications are that great changes do occur at the first fruiting phase of young coco-nuts.

In most plants the daily rate of water utilization is low in the vegetative stages of growth, but increases rapidly as the plants reach maturity.

The "cabbage" on a young palm, six years old, has easily the lowest percentage of dry matter, but practically double the percentage of ash found in any part of the plant at that age.

In the young palm, of the same age as above, the percentage of dry matter is low in the trunk; about 9 per cent. according to Sampson and increases to 49.30 per cent. in the bearing palm. There is an increase of dry matter also in the leaves but this is not nearly so marked between the two stages as for the trunk.

There is a significantly higher percentage of phosphoric acid in the ash of a young palm than in that of a bearing tree and apparently this element has most use in the young developmental stages. Experiments in this country have shown that it must be seldom that phosphoric acid deficiency symptoms develop in a coco-nut palm here. On some of the western islands, however, where phosphate deposits occur, very high yields of coco-nuts are obtained. In spite of this, single applications of phosphatic manures on old palms here have given no results, which appears to conform with the experiences elsewhere.

Many coral-derived soils under tropical conditions are low in lime content, due to excessive leaching of the surface layers. This is one factor which leads to their stickiness and liability to water-logging. In some places, applications of quick-lime, freshly slaked lime, or coral sand often give excellent results in increasing the yield of coco-nuts. In addition to its direct effect on the texture of the soil, this element has use in replacing potash in the soil and thus liberating this for the use of the crop. The probable significance of this fact in connexion with the disease at Namatanai (New Ireland) is thus clear, if it is known that there is heavier demand on the potash supply at the time the palms are coming into bearing. The soils there are of coralline derivation being acid or lacking in lime, until the actual limestone layer is reached, in addition to having low values for actual potash content.

In Bangalore, India, studies and analyses(33) to determine the plant food requirements of coffee at the bearing stage gave some very valuable results, which may be applicable to the coco-nut palm. A known number of coffee spikes, blossoms, set-buds and berries was collected, month by month, over a period of thirteen months and analysed for the essential plant foods, organic matter and carbohydrates, especially sugars. It was found that a large amount of potash was required and stored in the spike and blossom, prior to setting, and that this potash became distributed as the berry developed after setting.

The phosphorus requirements of coffee seem to be very steady and uniform, being about one-fifth the nitrogen content throughout the course of its development.

Coffee seems to require a steady and increasingly available supply of nitrogen throughout the course of its growth, not only to supply the ordinary nitrogen requirements, but, also, to maintain the nitrogen/carbohydrate ratio, which influences, in no small measure, the successful ripening of the fruit. This shows that the practice of applying complete fertilizers in certain stipulated proportions is well supported by physiological reasons. These experiments, although more specific in their objective, bear a close resemblance to Sampson's results from detailed analyses of different parts of the coco-nuts at varying stages of maturity.

Symptoms of Potash Deficiency.

Eckstein, Bruno and Turrentine⁽¹²⁾ in their book on *Potash Deficiency Symptoms* state, "a characteristic of potash hunger signs is that they usually first become noticeable after a certain period of growth of the plant is reached *(see* page 6). After a certain time, where potash is lacking, the plant attains a stage in which its potash content becomes so low that a normal functioning of metabolic (building up) processes is no longer possible and pathological phenomena develop. The symptoms of potash hunger are, therefore, variable with the different ages of the plant. Since the metabolic processes of the plant are also dependent on the weather, light, temperature and humidity, the signs of potash deficiency under otherwise equal conditions will be manifest in variable form and extent under different conditions of climate. Since potash has a very high degree of efficiency, typical potash starvation signs occur only after an extreme degree of potash deficiency is reached."

It will be seen that bronzing, yellowing, leaf spotting and die-back (similar to the appearance of leaf scorch in fruit trees) may represent extreme conditions of nutritional disturbance, whether due to actual manurial deficiency or to insufficient water and contained nutrients reaching the growing portions of the plant.

It is only possible to give a very brief *résumé* of the findings that potash deficiency exerts an unfavorable influence on the water utilization of the plant. This is due to this element causing both impairment of water absorption through the roots and increased loss of water through transpiration, which decreases the ability of the plant to withstand drought.

According to the authors quoted above, "in plants suffering from lack of potash the shoots develop at the expense of the roots; the latter are usually more seriously damaged than the aerial part of the plant. The production of secondary roots and lateral growth of the roots are materially injured. The relationship between transpiration and potash nutrition (supply to the plants) are the biggest factors in the impairment of the water economy of the plant, when potash is deficient. The presence of potassium tends to reduce the loss of water by transpiration and increase absorption. Lack of potash causes greater loss of water and wilting typical of potash starvation results."

Wallace⁽³¹⁾ has shown that potash deficiency has a greater influence on the root development of biennial and perennial plants than on annuals. It has also been demonstrated by several workers that the relationship between "potash deficiency" and "parasitism" (disease attack) is especially pronounced in perennial plants.

The general symptoms of potash deficiency in plants are that the leaves lack substance, hang down limply and the general appearance gives an impression of weakness and feebleness. Thus it is seen that such deficiency can lead to a condition closely approaching "leaf droop" without the appearance of outside organisms. It is a curious phenomena that plants suffering from potash deficiency at first go a darker green than in the case of a healthy palm, a phase which lasts for some time.

In more advanced stages, "leaf scorch", "necrotic and dark spotting", with leaves hanging down limply are common symptoms observed. There is collapse of supporting tissues in the leaves, and the root system is reduced. Finally, there is increased susceptibility to diseases, pests and climatic factors.

This discussion on potash deficiency symptoms only touches on the subject, as it has long been known that there must be a proper balance between the manurial constituents present, both in the soil and in the plant. As may be expected, the potash/nitrogen ratio is of the utmost importance in the nutrition of the plant. It is for this reason mostly that the results obtained from the use of balanced and complete fertilizers (applied in certain definite proportions) are much greater than those where single fertilizers only are used.

The degeneration of the midrib cells of the coco-nut fronds showing streaking, at Namatanai, may be due to cell dissociation caused by manurial deficiency (potash relatively low according to analysis), exaggerated by unfavorable water and nutritional relationships at the time the palms were coming into bearing.

Wallace(31) has shown that the nitrogen-potassium ratio is of the utmost importance. A wide ratio increases leaf scorching, while a narrow ratio reduces it.

Bain(2) as a result of analyses of very young palm leaves, from palms growing on both healthy and wilt areas, stated that "any differences which showed up were considered to be secondary to the seemingly more important water factor."

His general conclusion was that there was a high nitrogen status in wilt areas shown by leaf analyses, particularly in relation to phosphate or potash according to soil type. It was important to note that Bain found in some wilt areas that the percentages of potash in the young leaves were greater than in those from the healthy area.

Soil analyses or leaf analyses, considered by themselves, do not give anything like a full picture of the problem. The percentage amounts of potash and other nutrients found in various parts of the palm (especially when it is switching from the vegetative to the productive phase) are not nearly so important as the total amounts required for new growth and fruit production at critical periods. It is the sudden demand for water and nutrients normally required by a young palm, coming into bearing, not being met under unfavorable conditions of soil and climate, which leads to pathological symptoms.

There may be lack of balance of nutrition between nitrogen, potassium, phosphoric acid, and lime (or calcium) and magnesium. It is pointed out that there may be plenty of potash present in the soil, but it is not available to the plant, owing to lack of balance with the other nutrients present, unfavorable water relationships (which may be seasonal), or other causes. The largest proportion of the plant is built up with water, from the soil, and carbon dioxide, found in the air, through the action of sunlight on the green colouring matter or chlorophyll (photosynthesis). In this manner, starches, sugars, celluloses, fats, oils, plant acids and other compounds are synthesized. The direct nutritive effect of the water on the building up of carbohydrates (carbon compounds) and the necessity for respiration is not often stressed in relation to wilting and cell break down. Without recourse to actual figures it is absolutely certain that there is a tremendous increase in the total amounts of carbohydrates (starches, sugars, &c.), and oils synthesized at the time a coco-nut palm is coming into bearing, hence, there is a greater demand for water.

It is obvious that as far as coco-nuts are concerned there is plenty of room for research on the subjects indicated.

Potash Movements Only.

SAMPSON'S FIGURES(24) (CONDENSED AND TABULATED).

"Analyses of the different Parts of a Coco-nut Palm about Six to Seven Years Old (not yet bearing) compared with a Bearing Palm".

—	Root.	Stem.	Stipules.	Petioles. (Leaf stalk).			Leaflets.		
A. Young Palm % K_2O	.14	.50	.051	av. 74 (.12 old, 1.78 tender)			av. 1.08 (.55 old, 2.01 tender)		
B. Bearing Palm % K_2O	.29	.21	.034	av. 26			av. .56		
Percentage of K_2O (Potash) in the ash				Old.	Green.	Tender.	Old.	Green.	Tender.
A. Young Palm ..	3.33	10.89	2.68	3.92	4.24	34.60	13.75	18.13	40.94
B. Bearing Palm ..	8.27	3.91	3.50	av. 4.17			av. 13.08		

In comparing analyses of an inflorescence about to open with a similar inflorescence after the kernel of the fruit is formed, it is found that there is more than double as much potash in all parts of the young inflorescence, as compared with the older one.

The percentage of potash in the inflorescence (Spathe about to open) is, on a "barren" palm, 15.80 per centum, compared with 20.46 per cent. in a bearing palm.

Physiology of the Root System.

In order to give a better idea of the problem a very brief account of the root behaviour of coco-nuts is given. Copeland(5-6) and other authors have dealt with such physiological problems in detail.

All roots of the coco-nut palm have an impervious, rigid shell called the "hypodermis" which protects their structures, and gives them a very strong anchorage in the soil. The main horizontal spreading roots are like stout cords and both they and their larger branches bear numerous fine, much-branching roots which, in turn, may branch into much finer roots. The coco-nut palm has no root hairs, but the life history of their finest roots, like the root hairs of other plants, is very transitory.

The zones through which absorption of water and nutrients takes place is usually limited to the young growing part of the root, which has thinner epidermal or outer layers and thus allows the moisture and soil nutrients to be absorbed by osmosis. This zone is relatively short and is usually seen extending for just a few inches behind the hardened root-cap.

When the new growth of the roots is checked by dryness or other causes, the hardened, rigid shell (hypodermis) present on the older part of the root, tends to grow right up to the root cap and, thus, naturally limits the absorbing zone under unfavorable conditions.

As soon as the soil becomes wet again the roots revive, new root elongation occurs and absorption begins anew, through the thin, epidermal layers of the new portions or replaced roots.

The numerous, raised, light-coloured, outgrowths seen on the surface of all coco-nut roots are breathing organisms ("pneumatophores", really specialized reduced roots), through which the air supply to the roots and low internal system of the plant is maintained. These cannot function below the free water surface or in water-logged soils and, consequently, roots, growing under such conditions, either cease functioning or die altogether.

No roots will grow any distance into water, nor into a level of the soil where free water stands, also a rise in the water-level ultimately kills submerged roots. Sandy soils or pumice soils are naturally drier than heavy clay soils, and, in such free soils, the roots tend to grow deeper and maintain a deeper level than in stiff soils.

Duthie$^{(8)}$ says that, "as coco-nuts normally grow on poor soils (e.g., on sea-shores and coral atolls), it cannot be argued that potash and phosphate are the limiting factors present". This statement refers to a description of coco-nut wilt found on an acid clay soil, markedly deficient in available potash and phosphate, but with adequate nitrogen and organic matter.

It must be argued, however, that where the root system is restricted, manurial deficiencies, such as those indicated, must behave as important contributory, or inter-acting, limiting factors. Where palms are growing on poorer soils and are flourishing, it is because the proportionately greater and deeper root development in the loose sandy soil gives the roots access to a greater "total" of nutrients than where root growth is limited by heavy clays, or a high water-table. Further, in such free, sandy soils, found at the seashore, it is usual to have plenty of water available to the palm, which is charged with nutrients derived from the higher foothills and soil formations further inland. Under all circumstances, lack or exhaustion of nutrients will be felt, but it will have a much more pronounced effect where a restricted root system limits the total amount of moisture and nutrients available in an already deficient soil. That the nutrient content of the soil is most important in maintaining the healthy production of coco-nut palms is well illustrated on Witu Island, where the volcanic soils are very rich. There coco-nut palms are heavy yielders in areas where the soil is no more than 12 inches to 15 inches deep and rests on new volcanic rock which entirely restricts the root-growth below that level. This would not be possible in a soil deficient in nutrients.

Copeland⁽⁶⁾ investigated, in detail, the water relationships of the coco-nut palm during drought conditions. It was found that after a prolonged drought in one district of the Philippines, it took palms two years to recover. He commented that "the injury to the palms' vitality during a prolonged drought is so severe that the return of favorable weather conditions is but slowly followed by resumption of normal activity. When adequate rains come the roots must awaken from a defensive rest, in which a prompt response cannot be expected. A constant supply of water must be at the disposal of the coco-nut, or it will protect itself against injurious desiccation by a partial suspense of vitality".

Rooting of the Palms and the Necessity for Root Adjustment.

Soil conditions, such as those described in this article, undoubtedly lead to shallow rooting, except where the soil is well drained by creeks or main drains. Whether the roots go deeper or not they can only take up limited supplies of nutrients below the water surface, also the fibrous roots and smaller roots tend to die off in zones of poor aeration, as aeration is necessary for water and nutrient absorption. Thus, although plenty of water is present, conditions of physiological drought and reduced nutrient supply may occur, even though there are plenty of manurial ingredients present in the soil. If, by any chance, previous cropping with exhausting crops or lack of the main essential ingredients (nitrogen, phosphate, calcium and more particularly potash) is in evidence, this effect may be increased. It is seen that soil analyses are of great assistance in solving disease problems associated with soil nutrition.

Such causes as those indicated above can lead to cell collapse and breakdown, as for example some forms of bud-rot caused by unfavorable soil and moisture relationships, mainly, have been recorded from many sources. In the change-over period from wet to the dry season, where soils are liable to waterlogging and compaction after drying out, there is decided necessity for root adjustment. This often has marked physiological effects which are reflected in the behaviour of the palms. There is too much moisture in the wet season which leads to reduced nutrient intake and loss of roots. It is likely that in the dry season (particularly in abnormal periods), there is too little moisture present which, owing to compaction of the clay and the fact that the clay does not give up water quickly, would also lead to upset of the palms. The roots could be expected to grow and function better as soon as more rains are received, hence, in a plantation subject to a seasonal bearing, the best yield should be obtained from the beginning to the middle of the wet season.

It is feasible to believe that some form of seasonal adjustment is the natural behaviour of all coco-nut palms, excepting where the water-table exists at a relatively constant depth in a friable soil.

This root adjustment only leads to pathological symptoms becoming apparent under abnormal climatic conditions (e.g. too much or too little rainfall), where the soil and water-table do not favour normal root development.

It appears likely that seasonal bearing, nut-fall, leaf-droop, and often loss of palms (such as is found in coco-nuts growing on the Madang coast) may be due to fluctuating climatic and soil conditions affecting the behaviour of the roots and thus the water and nutrient supply to the palms.

Moisture Requirements of Coco-nut Palms.

No work has been done on this problem in New Guinea, but a good deal of investigation has been carried out in the Philippines.(6–11)

In making injection experiments the writer observed when introducing culture solutions through numerous ¾-in. auger holes, which were about 4 inches deep and sufficient to hold 50 C.C. of water at one time, that hundreds of grammes of water were taken up, almost as quickly as they were introduced, on bright, sunny days. In the early morning and on rainy days the rate of absorption was very slow.

During a long wet season, when there are numerous consecutive cloudy days, moisture absorption and utilization by the plant are greatly reduced, despite the abundance of water present. In the dry season the rate of absorption is greatly increased, as is the transpiration. The palms have natural adaptation in the leaves for regulating transpiration to some extent.

The pinnae (leaflets) are adapted for folding longitudinally and thus lessen transpiration by protecting the stomata (breathing organs, found in the leaves) from undue evaporation. There are no water storage organs found in the coco-nut palm, such as are found in numerous other plants.

Espino and Juliano(11) carried out detailed investigations on the absorption of culture solutions by coco-nut palm roots. They showed that the rate of absorption was 233.33 per centum more rapid during rainless days than during rainy days. The wind makes a decided difference in the transpiration of the leaves, but makes a much greater one when the leaves are in full sunshine, as is more usual in the dry season.

Copeland(5–6) reports that a coco-nut palm can absorb 24 litres (54 lb.) of water per day, from root absorption experiments, but from determinations of evaporation from the leaves, he is inclined to place the figures at from 28-45 litres.

Espino and Juliano (*loc. cit.*) from a different set of calculations place the water requirements as 16 litres (36 lb.) per day.

Whatever figures are correct, they are all of a high order and explain why palms flourish so well at low levels (sea-shores and islands) in the tropical zones.

The annual requirements of a coco-nut palm requiring 36 lb. per day would be 13,140 lb. and for one requiring 54 lb. per day would be 19,710 lb. Thus the requirements per unit area (acre or hectare) are constantly very high.

All investigators agree that there is a very close correlation between absorption and transpiration. The absorption of nutrients by the palm depends on two sets of factors—those that occur inside the plant (physiological) and those that occur outside the body of the plant (environmental). Among the important factors determining absorption are the age, the health of the plant, and all of the factors which govern the rate and amount of transpiration.

The amount of transpiration depends upon the temperature and humidity of the air, rain, wind-velocity and the growth activities of the plant.

Where unfavorable moisture conditions occur, and in times of severe drought, the older leaves fall off or die back with unusual rapidity. It has been proved that the older leaves are the ones which would lose the most water; the tree cuts down its water requirements in this way, to a very considerable extent.

In several instances here, when the palms were growing under unfavorable conditions, or during abnormal weather periods, one has seen the ground literally littered with leaves. There is a tendency for this fall of leaves to occur within a very short space of time under certain conditions.

When root growth and absorption are greatly reduced, as usually follows physiological droughts, or dry periods, then the whole of the top growth is reduced proportionately. It may happen that the growth slows up completely or is reduced to such a degree that the fronds fall off altogether. If the conditions are permanently unsuitable, premature ageing of the palms may result, unless the soil conditions are improved.

It seems feasible that "leaf-droop" occurs where the moisture and nutrients supply of the palm are greatly reduced, so that the palms tend to shed a high proportion of their leaves to balance the absorption to the supply available. Where the palms are not sufficiently vigorous to shed their leaves, or where their vigour has been further reduced by other contributory factors, e.g., fungus attack, then these leaves remain attached to the palm in the familiar manner already described in the previous article on coco-nut diseases.(9)

Duthie(8) compared the soil moisture relationships in soils from healthy beds and those carrying palms liable to wilting . In the case of the heavy, clay soils under investigation he concluded that the slow lateral movement and availability of the moisture in compact, clay soils were key factors leading to the appearance of the diseases. It is not the gross moisture present in the soil, but the amount of available moisture which is most important. The wilting point in a clay soil may occur when there is more than 13 per centum moisture present in that soil, especially where there is a high percentage of salts (sodium, magnesium).

Such salts when present in high concentration hinder absorption through the roots. Physiological and chemical analyses of the New Guinea soils are very lacking as far as such data is concerned. It is pointed out that as the percentage of water to dry matter in a young palm is much greater than that in an older palm, the water requirements of a young palm, in proportion to its size, are greater. This helps to explain the greater susceptibility of young palms to drought conditions. Copeland(5) maintains that proper physical composition of the soil is of a great deal more importance than its chemical composition, if only the palms are able to secure sufficient water. It appears that both are important but the physical relationships of the soil are not usually given sufficient prominence.

Restriction of Water Supply Due to Disease and Injuries.

Waterlogged soil and fluctuating climatic conditions which are often not optimum for the growth of the coco-nut palms favour insect and fungus attack.

The bleeding fungus (*Thielaviopsis paradoxa*) does most damage in wet situations and often causes hundreds of lesions to develop on the trunks, some of which become large and deep seated. Even though the palms recover from such attacks a good deal of conducting tissue is destroyed, which naturally reduces the water supply to the palms.

Thread Blight (*Corticium penicillatum*), as a general rule, only assumes serious proportions under wet conditions, in wind-locked areas. This fungus destroys the fronds and reduces water absorption under conditions where maximum leaf area is required for the palms to flourish.

" Frond-fall " and " leaf-droop " which are usually most prevalent in waterlogged and deficient soils, both lead to a reduction of the total number of fronds and reduce the water supply to the palms. Where the fronds fall off prematurely the soft tissues are exposed to beetle attack. After severe beetle attack half the diameter of the trunk may be destroyed and, although the palms recover, the water and nutrient supply to the palms are reduced for all time.

Severe burning off, such as is practised on some plantations here when the undergrowth is out of control, in addition to burning the humus from the soil, destroys the superficial layers of the palm trunks. This greatly reduces the water conducting tissues. The influence of such diseases and injuries as those outlined, greatly aggravates the effects of adverse climatic and soil conditions on the general health of the palm.

MATURE PALM WILTS AND OTHER PHYSIOLOGICAL DISEASES.

There are mature palm wilts and other physiological derangements of coco-nuts present in New Guinea which are due to palms growing on soils with unsuitable profiles, which are subject to waterlogging in the wet season and to drying out and compaction in the dry season. In mentioning instances of this, some very good examples are to be seen on the mainland of New Guinea, in parts of the Markham Valley, near Lae, and in the plantations around Madang, located on estuarine formations. Similar occurrences have been noted in the Kavieng districts, also in Manus, and the Admiralty Islands, on varying classes of soil, but more especially where stiff, clay-soils overlying coralline limestone are present. The question is whether these mature palm wilts are to be classed in the same category as " maturation wilts " where the particular stage of growth and the change in the chemical composition of the plant itself comes so much into play.

The late Dr. H. R. Briton-Jones has clearly recognized the difficulty in classifying wilt diseases of coco-nuts in his second treatise on the subject.(4) He remarked that " the causes of the unsuitability of the conditions for coco-nuts in different soils may be entirely different. In one case, it might be due primarily to the physical texture of the soil, whereas, in another, it might be due to the chemical composition of the soil or even to a combination of certain physical and chemical factors ".

This appears to indicate the crux of the position, and, further, it indicates how this problem of wilt diseases is so closely related to deficiency problems as a whole and to the retrogression of coco-nut areas, which is becoming more and more common in plantations here.

It seems a safe deduction that the soil profiles, the climatic environment and the cultural conditions in New Guinea would seldom duplicate those found in the West Indies, hence we may expect different responses from the coco-nut palms under the particular circumstances prevailing here.

It would appear that coco-nut wilts of the "bronze leaf" type are not nearly so severe or prevalent in this country as in the West Indies. Certain of the external characteristics of the diseases described in this article do not seem to correspond with those described by Briton-Jones,(4) Bain,(2) Duthie,(8) and others.

The possible explanations as to why coco-nut wilts are not common here are many, as, for example, most parts of New Guinea are classified amongst the wettest tropical countries in the world. Except on some areas of the mainland, the soils are all geologically new where coco-nuts are grown.

Culturally, in New Guinea, sugar-cane is never intentionally replaced with coco-nuts or vice versa, and interplanting coco-nuts with sugar-cane is not done. In very limited areas coco-nuts planted here may have replaced small areas of native-grown cane for edible purposes or patches of wild canes.

Briton-Jones, in 1928,(4) decided that there were two forms of the root disease (wilting) of coco-nuts recorded by Stockdale(28) and Nowell(17) in Trinidad, which he named, respectively, "bronze leaf wilt" and "yellow leaf" or "tapering stem wilt". In the former the leaves are a highly-coloured yellow to bronze or may assume a reddish-brown colour. The latter is distinguished by a yellow discolouration of the leaves progressing from the tip backwards, while all the leaves, including the central ones, become dwarfed, and it is a chronic malady whose history and effects have not been worked out. His observations in Trinidad and some of the other West Indian islands led to the opinion that the onset of "bronze leaf wilt" is in the majority of cases due to physiological drought, which does not need a prolonged period, but may become evident after a short, dry period under certain soil conditions, especially where the soil is heavy, badly drained, and subject to desiccation in the dry season.

The soils on which the disease is serious were said to be generally heavy, in very bad tilth and constitutionally such that they do not drain well, but dry out rapidly and crack in the dry season. The very definite correlation between lack of drainage and the incidence of the disease indicated that any organism present was a secondary factor, and the primary cause is suggested very strongly as a soil factor.

The general wilting of coco-nut palms often seen after a long spell of dry weather in portions of New Guinea (e.g., the Gazelle Peninsula, New Britain), with usually a subsequent recovery when the rains occur, shows some features in common with the above occurrences. It is, however, usually seen on light, porous soils with poor water-holding capacity. The lower leaves do brown off and wither, but these palms immediately respond to good rains. This browning off after a drought and subsequent recovery is not the same as bronze wilt and does not explain the conditions met with at Kokopo and Namatanai and elsewhere in New Guinea.

Park(19) refers to the effects of "drought" on coco-nuts in Ceylon. He first suspected bud-rot infestation, as one estate of 100 acres contained 600 dead or dying palms. The standard of cultivation on the estate was poor, and it was found that the condition was due to the effects of drought, while the buds fell off from mechanical causes only. He stated that "the condition was comparable with 'bronze leaf wilt' disease recorded by Briton-Jones, in Trinidad".(4) The condition was worst on low-lying land, liable to water-logging in wet weather, due to this water-logging causing the palms to become shallow-rooting. The effects of good cultivation were marked under these conditions, and drainage to induce deep rooting was advocated.

Patel(20) says that, "in the red soils of India, palms suffer through drought in the summer. It is possible that some mineral nutrients available in the soil may not be absorbed by the palms, because of some limiting factors such as moisture".

Briton-Jones(4) experimentally reproduced bronze leaf symptoms in healthy palms, under suitable conditions, by digging trenches around them. Another very interesting experiment was where he induced some leaves on one side of a palm to turn to a bronze-yellow colour by cultivating on that side to a depth of 3 inches, thus cutting the root system within the cultivated area.

According to Bain,(2) "bronze leaf wilt" is considered to be a physiological die-back of the palm, as a result of water deficiency in the plant. After a long investigation, he concluded that "the 'Trinidad wilt' was due to the curtailment of root growth by a high water table at certain times of the year, followed by dry seasons, which the restricted root system could not withstand and function properly".

The close approximation of the soil conditions described and the development of this type of root-growth in palms growing in certain areas of the Madang coast, as described elsewhere, are worthy of note.

It is seen that certain soil factors, particularly water-logging, which militate against the plant producing an effective root system, operate in wilt areas, and it has been clearly indicated that bronze wilt may occur in several types of soil. It would appear, therefore, that the factor to be particularly stressed in this disease is a water deficiency in the plant, the differences in nutrient status being considered as contributory factors. The disease should be extra prevalent in a dry period, following an abnormally wet season, and apparently field observations have confirmed this. It will be shown elsewhere in this article that many other disease symptoms found in coco-nut palms in New Guinea are worst under the particular conditions mentioned, as one may naturally expect.

It was been recorded that,(2–8) "in all plantations where 'bronze leaf wilt' was noted in Trinidad, the palms were planted generally at what appears to be just about half the proper distances apart (about 15 feet and in some cases 20 feet)". The range of spacing of coco-nut palms on the main plantations in New Guinea is from 25-36 feet, and is usually about 30 feet.

Curiously, the occurrence in young palms at Namatanai was on areas where the spacing was rather wider than usual, at about 36 feet. The only places where close planting is resorted to here are on the native groves, where frond choking does occur owing to light competition, but wilting appears to be very rare.

Bain(2) says that "the usual age at which palms die from the disease is from 15 to 18 years". If this is the period at which palms come to the bearing stage there, it seems that the palms come to this stage much later than in this Territory, probably owing to the late planting and the different soil conditions, &c.

Duthie, writing on "Coco-nut Wilt, in the Essequibo and Pomeroon Districts of British Guiana",(8) says that "Bain's findings explained the puzzling fact that trees grow normally for several years, as even a relatively small root system is sufficient to keep young trees in good health, but the strain of bearing is usually the critical point. Trees 15 to 25 years old are affected on the Essequibo coast and the symptoms are almost identical with those in Trinidad. The disease occurs both on clay and sandy soils."

His investigations were confined to the clay soils and he found the wilt occurring on an acid clay, markedly deficient in potash and phosphate, but with adequate nitrogen and organic matter. It was shown that the accumulation of saline substances (magnesia and soda) in the subsoil of the wilt area indicated lack of aeration and drainage, even though the soil was not waterlogged.

The following conditions were listed as leading to wilt in British Guiana:—

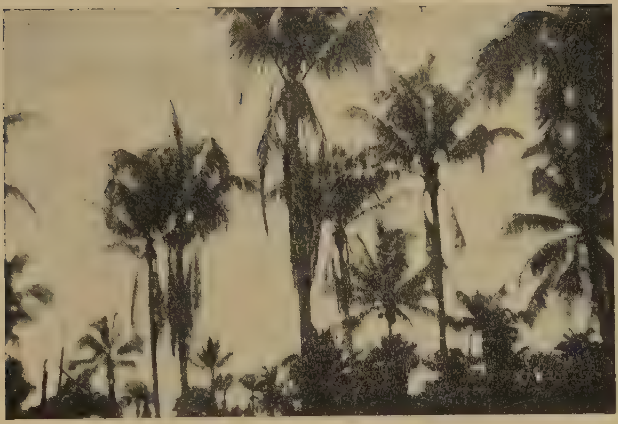
> The widespread cultivation of sugar-cane led to large areas being changed from bush to sugar-cane—a shallow-rooted grass crop which exploits the top 18 inches of the soil and leaves the lower layers free from roots. The wilt disease of coco-nuts on the heavy, clay soils of the Essequibo coast is probably caused by planting coco-nuts on old cane beds where the sub-soil is too compact and saline to allow easy root penetrations, with the result that the top soil becomes a mass of roots and the percolation of water is greatly hindered. The trees are thus living on the verge of drought, and the effects of physiological drought were also important owing to the high content of moisture and soda even in the top soil. When evaporation from the soil surface is increased by 'clean cultivation' or by the death of a few trees, wilt appears and spreads slowly in the direction of the prevailing winds.

The type of soils in which this wilt occurs, the chemical status and, further, its occurrence after the growing of the exhausting crop sugar-cane should be carefully noted for comparison with New Guinea conditions. Duthie's description also largely conforms with the conditions found in Trinidad.

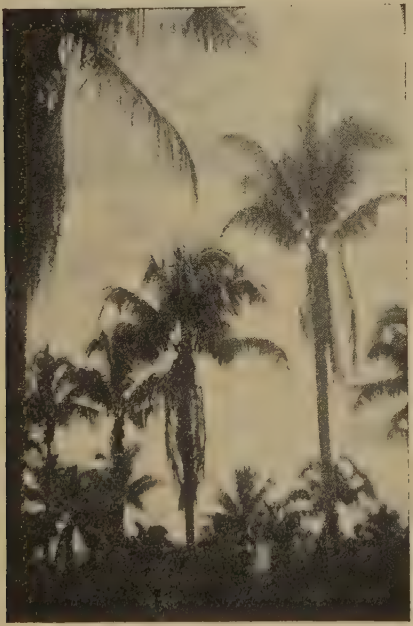
Mature Palm Wilt on the Huon Gulf.

The nearest approach to an extreme case of "mature palm wilt" resembling the "bronze wilt", such as one has seen depicted from Trinidad, was seen recently on a plantation situated in the Huon Gulf area, on a plain apparently representing the old delta of the Markham and Adler Rivers. The areas planted with coco-nut palms, ranging from 21-27 years old, were covered by a dense undergrowth of grasses and weeds, such as Kunai, *Imperata arundinacea, Saccharum spontaneum* (wild sugar-cane), and many other grass-types, also bananas and cassava, *Manihot utilissima* (which had been previously planted and run wild).

"Leaf-droop" and "leaf-break" were most abundant and were very prevalent, while the palms were stunted and bearing poorly. In many areas, tapering stem, yellowing and bronzing of the fronds, and reduction in the size and number of the fronds, were most noticeable. The erectness of the few fronds left, their feathery, open nature, and poor colour and vigour, showed conclusively that the soil and cultural conditions were at fault (*see* photographs).



Coco-nut Palms—Mature. Affected by unfavorable soil conditions; non-bearing, also "leaf-droop" and "taper stem" present. Two palms with heads missing.



Coco-nut Palms affected by soil conditions.

N.B.—Palms—non-bearing. Fronds—feathery, reduction in size and number. "Leaf-droop"—present.

In some places the very strong-growing, soil-exhausting creeper, *Ipomœa robusta* (sweet potato type), was seen growing over the trunks and into the branches of the palms. Several palms were seen to be left as bare poles only, with the cabbages collapsed and fallen off. Stem-bleeding, due to the fungus *Thielaviopsis paradoxa,* was seen on many of the palms.

The frequent gaps in the plantation showed that the loss of the palms had been high in the past. The general appearance of the plantation suggested unsuitable soil conditions, and extreme manurial deficiency, which from the scorching and bronzing present on the palm fronds was apparently an inter-action of potash deficiency combined with physiological drought. The conditions were undoubtedly intensified by lack of care and attention, probably increased by burning off and the presence of so many strong-growing, soil-exhausting grasses and weeds, most of which have a heavy drain on nitrogen, but particularly on potash. The soil profile, however, showed the main reason for the state of the coco-nut palms here, when the inter-action with the other factors mentioned are taken into account. The surface-soil was a stiff clay loam, liable to waterlogging in the wet weather. The sub-soil was a very compact and small-grained clay, caused by deposition of the fine particles. At varying depths below this clay sub-soil, coarse rubble layers composed of water-worn pebbles were met. In the wet season there is a mass movement of water through these rubble layers from the high hills behind, so that almost a free water surface is presented. The surface layers were liable to waterlogging, with the presence of a superimposed

Coco-nut Palms, showing dense undergrowth, such as *Ipomœa robusta*, climbing on trunk. N.B.—Stunted and poor condition of palms, also "leaf-break" present.

water table in the wet season and to drying-out and cracking in the dry season. Obviously the rubble layers hasten the loss of water from the soil and sub-soil in the dry season. It will be seen that these conditions somewhat approximate the conditions seen in the Madang district. Owing to the presence of grasses, wild sugar-canes, native food crops, wild bananas, &c., which would not be present on a well-kept place, the chances of deficiency and unsuitable water-relationships causing severe symptoms are greatly increased. It is also apparent that this set of circumstances would more closely represent the extreme conditions found in the West Indies, where coco-nuts have been previously grown for several years.

Where unsuitable soil conditions exist, and the plantations are badly treated as concerns lack of drainge and the growing of exhausting crops, there is, in the future, considerable likelihood of many other areas showing "mature palm wilt", some forms of "bud-rot", and related symptoms.

Particulars of Some Areas Where Physiological Derangements of Coco-nuts Occur.

All of the plantations where clay exists hold the surface water after heavy rains, except where creeks and running streams provide adequate natural drainage. The coco-nuts in the naturally-drained areas bear quite well, thereby showing that drainage is essential for all the undrained areas of similar soil type. Some typical soil profiles from waterlogged areas in the Astrolabe Bay area, where palms are very stunted and surface water is often found right to the surface, are now described.

When holes are first sunk, the water is seen at about 6 inches from the surface, but usually fills and runs over at various periods. The ground is very clayey down to 4 ft. 6 in., being slightly freer at the surface. At a short distance from the surface there is usually a hardened pan of deposited clay, blue-grey in colour, showing poor aeration and the presence of unoxidized iron. Even at the surface the clay was very puggy, but much more so in the compacted layers where the very fine-grained, colloidal particles are washed down and deposited. Such soil conditions are totally unsuited for plant growth, or nutrient intake. Under ordinary conditions heavy clay soils give up their nutrients slowly, owing to colloidal attraction. It is almost impossible for a coco-nut palm to take up its food from such a soil under water-logged conditions, or, conversely, when the soil has set very hard in the dry season.

Typical soil profiles in areas liable to forms of "mature palm wilt" vary somewhat as to actual depth of the deposits, but usually conform to the same type. In one water-logged area, the face of a creek showed first a shallow, dark humic layer on top, then a stiff clay loam (about 1 ft. 6 in. to 2 feet deep) overlying a very stiff, clay sub-soil, which reaches to a depth of 5 feet. Then, from the bottom of this clay to 15 feet down, alternating layers of pebbly gravel (rubble) with sandy layers intervening were seen. This type of deposition appears to be associated with the streams running from inland through the plantation, or, in other words, are estuarine deposits. In this particular case, it was derived from the shifting mouth of a comparatively large river.

Underground Water.

The whole of the area subject to the palms dying off has an extensive underlying free water-table, at no great distance from the surface. The level of this main water-table usually corresponds with the level of the water in the running streams present, which are usually quite shallow in the estuarine areas. It seemed practically certain that there is a superimposed, secondary, water-table which is only in evidence in the wet season, or in periods of heavy rainfall. This secondary water-table is only a few inches from the surface, in the wet areas, and is held up by the compacted zone of deposited clay (which acts as a hard pan), assisted by the flatness of the land and the lack of drainage. This raised water-table lies near the surface during the whole of the wet season, but, in the comparatively short dry season, the ground dries up, sets very hard, and compacts. This is especially so in the case of the non-bearing areas, where the water tends to lie all over the place. In the dry season, under these particular conditions, even the grass and weeds stop their growth to a large extent. The change-over period from the wet to the dry season greatly affects the nutrition of the plant and plays a most important part in the development of deficiency symptoms leading to stunted growth, leaf-droop, nut-fall, and so on.

In the bad water-logged areas mentioned, the palms range from 10-20 feet high, while nowhere are they higher than 40 feet, even in the best areas, where the soils are so heavy. Numerous palms in these areas show constriction of the trunks at a few feet above the ground level with evidence of a later recovery of diameter to a limited extent, which illustrates the effect of neglect in the early stages. Where the palms are stunted, with tapering stems, and non-bearing, this is a direct reflection of the soil conditions and related root development.

The high water-table and water-logged state of the soils following heavy rains are very deleterious to the healthy growth of the root system, as this prevents air intake below the water level and interferes with it in the saturated zone. Because of this fact, and despite the excess of moisture present, it is impossible for it to be absorbed by the roots. Consequent on the reduced water supply to the palm is a reduced intake of nutrients and untimely death of the roots.

In many places the palms are reduced to getting their air and nutrient supply from the top 6 inches of soil during the wet period and after prolonged periods of stagnation either the roots die off or become sickly below the water level. In the dry reason the soil cakes and compacts, and the heavy clay soils give up their moisture very slowly to the reduced root system. The palms often show a partial recovery towards the end of the dry season, when new roots develop and cause more water and nutrients to become available from the lower sub-soil layers.

It is pointed out that the presence of the estuarine rubble layers underneath the soil layers assists the water getting away in the dry seasons and leads to a greater contrast, between the wet and dry seasons, of soil conditions than would otherwise occur. Extremely bad cases of unsuitable soil profiles such as those described above may mean that the ground is totally unsuited for coco-nuts, especially where drainage is impossible or uneconomic. The pronounced seasonal bearing in the plantations on this coast is closely related to the fluctuating soil and climatic seasons (*see* graph). The change-over periods from the wet to the dry seasons or vice versa are believed to be critical seasonal periods for the coco-nut palms, and to have a pronounced influence on both seasonal bearing and the occurrence of nut-fall in coco-nuts, where heavy, water-logged soils liable to drying out are present.

Seasonal Variations In Yield.

It is not intended to discuss this problem for New Guinea as a whole, but to relate the seasonal fluctuations in yield of certain plantations with the moisture and nutritional status of the soils already described, and to indicate other reactions of the palms to these particular environments.

The monthly yield of one plantation, in particular, is discussed where the tendency to seasonal bearing is pronounced. In the three years considered November, December and January are usually peak months for production, while March, April, May and June are months of comparatively low yield of copra. If, for the three years, the total monthly yields as bags of copra harvested are compared, the following interesting facts are revealed. The total number of bags harvested in the three high yielding months are as follows:—November (902), December (914), and January (900), giving a total of 2,716 bags. In the three low yielding months the numbers of bags harvested were for April (680), May (624), and June (715), giving a total of 2,019 bags, which represents almost a third reduction in yield compared with the former three months.

This seasonal variation in yield is undoubtedly due to a seasonal inter-action between the soil, climatic factors and the nutrition of the plant, and is what one would expect under the conditions prevailing on most of the plantations around the Madang district, particularly on those properties which are situated on deltaic deposits in the extensive Astrolabe Bay area.

Under the particular conditions obtaining at Kasaragood, India, Patel has shown by mathematical calculations (regression, co-efficients, and significance of yield) that the rainfall of the year previous to and of the year of the harvest is significantly correlated with yield.

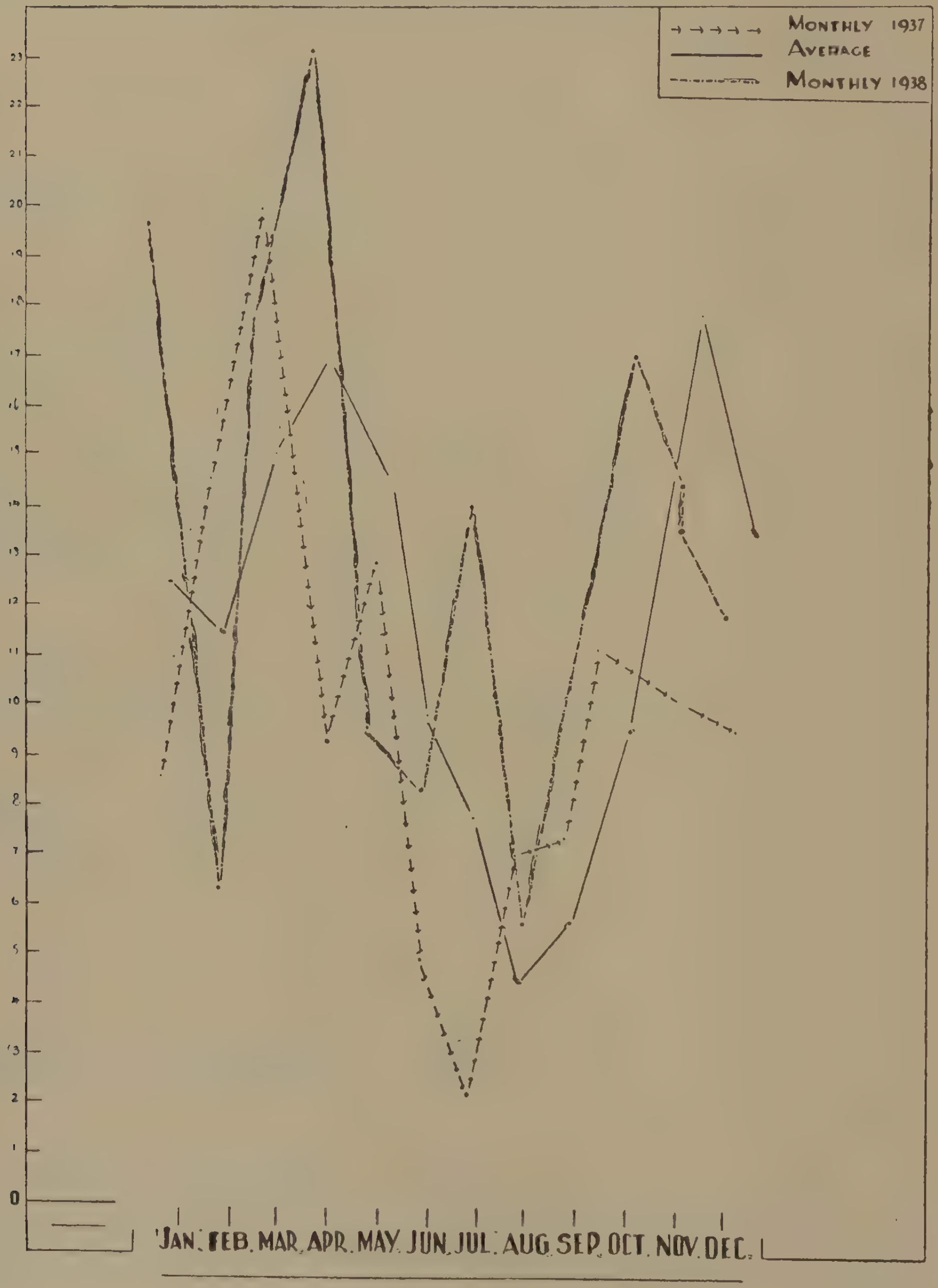
Climate and Rainfall.

The only complete rainfall figures available in this office, concerning this particular district, are from the Government observation station at Madang, though scattered rainfall figures are recorded on the plantations under consideration.

The average annual rainfall at Madang is 136.36 inches over twenty years, and it may fluctuate between 90 inches and 165 inches during individual years. There is usually a long wet season of seven months duration, from November to May, with a short dry season, usually of only five months duration, from June to October.

RAINFALL GRAPH, MADANG.

MONTHLY RAINFALL (1938): AVERAGE FOR 21 YEARS (1917–38): MONTHLY RAINFALL (1937).



The appearances are that both the maximum and low yields are recorded at the beginning and end of the wet season respectively, but this may be misleading as to times at which the causes leading to the actual losses in crop occur. The peak months are March, April and May, while August and September are the driest months and, as seen, the lowest yields are recorded in April and May, which, however, ranges from five to six months after the rainfall season has begun. The fact that this reduction in yield is more apparent at the end of the wet season and lasts into the change-over period is worthy of note.

The period of maximum yield is where regular and moderate rainfall conditions are experienced immediately after the dry season. The high yields seem to commence immediately the dry season is over, when the soil is not water-logged, and sufficient rainfall occurs for the palms to set satisfactory crops.

There may be both immediate and long term effects (or seasonal and annual responses) to seasonal conditions. The effects of drought on reducing the following year's crop is well known. The fact, however, that poor, or optimum, fruit-setting conditions in a particular part of the season may not be evidenced till twelve months later is not often recognized. Where the seasonal effects on yield occur in the same crop, this may be due to either the full crop not being carried to maturity owing to nut-fall, or, conversely, to spathes and already mature nuts being carried down over on the palms and dropped together at a later date. This latter occurrence is not uncommon on poorly vigorous palms.

Nut-fall of the Type Related to Soil Conditions.

Stockdale(29) has briefly described nut-fall from the Kurunegala district, Ceylon, where the rainfall was said to be rather excessive for optimum growth of the coco-nuts and the soils heavy. It was only under these conditions that "nut-fall" and "leaf-droop" proved serious in Ceylon, and under excessive and continuous spells of wet weather proved capable of considerable damage to palms and crops.

Gadd, in 1923,(13) stated that "in Ceylon it was shown that water deficit following on a prolonged drought caused greatly increased fall of the 'female flowers', or 'button nuts'. Such abscision of 'buttons' and youngest fruits may be caused by periods of drought as may the falling of larger nuts".

He indicated, however, that "nut-fall" in Ceylon occurs principally in the rainy season, and in the districts where it was particularly severe the soils were heavy loams which become hard during the dry weather, with a tendency to water-logging in periods of excess rainfall. These particular soil conditions, during heavy rains, become deleterious to the healthy growth of the root system by interfering with the air supply, which despite the excess of moisture present leads to reduced absorption of water, and untimely death of the roots, resulting in nut-fall.

The reader is referred to the New Guinea *Agricultural Gazette,* Vol. 3, No. 1, pages 58 to 70, for a detailed account of nut-fall in coco-nuts where the various kinds of nut-fall are described.(9) The purpose of the discussion included here is to show that nut-fall can be closely related to deficiency of water and nutrients in certain types of soil. The nut-fall problem in New Guinea is elucidated on page 62 of the same article, where it is stated that severe incidences of nut-fall have been recorded only at intervals on plantations in this Territory.

The fall of buttons and of large nuts up to 10 inches in diameter was noted in certain areas near Madang with soil horizons as described previously, and, also, in other plantations in the same district, where stiff clay soil rested on a loose foundation of decomposed coral. In these areas there was no great depth of soil on top, and, owing to an intervening zone of deposition, or probably due to an excessive lime status, the coco-nut roots did not extend far into the coral layers.

In the limestone soils of coral atolls in this Territory (e.g., in the Western Islands) there is generally deposition of secondary limestone hard pans due to the leaching action of the water. The lime is leached out by the water and deposited at certain depths, where it has a typical mortarising effect and firmly cements the fragments of sand.

Brackish underground water is present at relatively constant depths right throughout the coral atolls. The small difference in height from the surface to the water in the various places is more dependent on the slight irregularities of ground elevation present. On the higher ground on the margins it is rarely more than 5 ft. 6 in. to the free-water level, while it rises to the surface in the lagoons, and over wide intermediate areas the water is only at about 1 foot to 18 inches from the surface.

The holding up of the surface water by the lime-impregnated layer would lead to increased water-logging in very wet seasons.

In the lagoons and swampy depressions, however, it is the excess of free brackish rather stagnant water coming to the surface which restricts the root-growth and makes the areas unsuited for growth of coco-nut palms at any time, as is seen where they are dwarfed or lean over.

It was seen from soil profiles examined that underneath some areas it was no distance to a second lime-impregnated layer, below the free water surface of the true water-table, which was practically impervious to water. Below this at varying depths solid coral is usually met with its lime-infiltrated coating, which also prevents the free water level dropping far.

It would be thought that the presence of this underground free water should ensure that any water shortage would be unlikely. This, however, is not the case and the best coco-nuts on these atolls are very prone to seasonal bearing and are affected by seasonal conditions.

The yield of copra falls off badly after long dry seasons.

The shallow rooting of the palms in most areas here and the tendency for them to fall over and show flat plates of hardened mortar-like ground at their bases has been described in a previous article.(10) The superimposed limestone hard-pan mentioned does not entirely prevent root-growth, but below this layer the roots are usually constricted, gnarled and not well developed.

In addition to the restrictive action on the spread of the plant roots, it also causes retention of the surface rainfall, near the surface in the wet seasons, despite the fact that the surface soil is loose and sandy. It is also believed that this layer has the effect of limiting the amount of nutrients available. The loose, sandy, surface soil leads to a quick drying out in the dry season and reduces the water and nutrient supply to a restricted root system. Stunting, deficiency symptoms in the palms and fall of poorly developed and unfilled nuts is common under these conditions as is "leaf-droop" and seasonal bearing. The effect of the physical conditions mentioned are closely inter-related with soil exhaustion and lack of nutrients which has caused the palms on so many of the older areas to retrogress in vigour and production.

In the plantations of New Guinea, there is reason to believe that any physiological upset of the palms and nut-fall which occurs is worse in the change-over period from the wet to the dry season, although a certain amount may occur all the year round.

The occurrence of nut-fall as indicated is undoubtedly a question of unsuitable soil and water relationships. Few insects or fungi could be seen present on the base of the fallen nuts at Madang. It is fairly safe to conclude that physiological conditions are responsible, and the organisms present serve to increase the effect. It appears that a much heavier crop is set at flowering time than is carried to maturity, simply because under unfavorable circumstances the palms cannot carry a full crop.

It is the opinion of Dr. Tammes(30) of the coco-nut experiment station at Manado, Celebes, N.E.I., that "It seems that the number of fruits produced is not limited by the number of flowers nor by pollination, but is exclusively controlled by the physiological condition of the nutrition of the tree. A very important factor is the available quantity of water."

The present author does not entirely subscribe to the above conclusion, but there is no doubt that the water relationships do play a very big part as where there is too little water present, or where too much water in the soil leads to physiological drought owing to root restriction and reduction of water intake.

Influence of Soil-exhausting Crops on Wilt and Disease Occurrences.

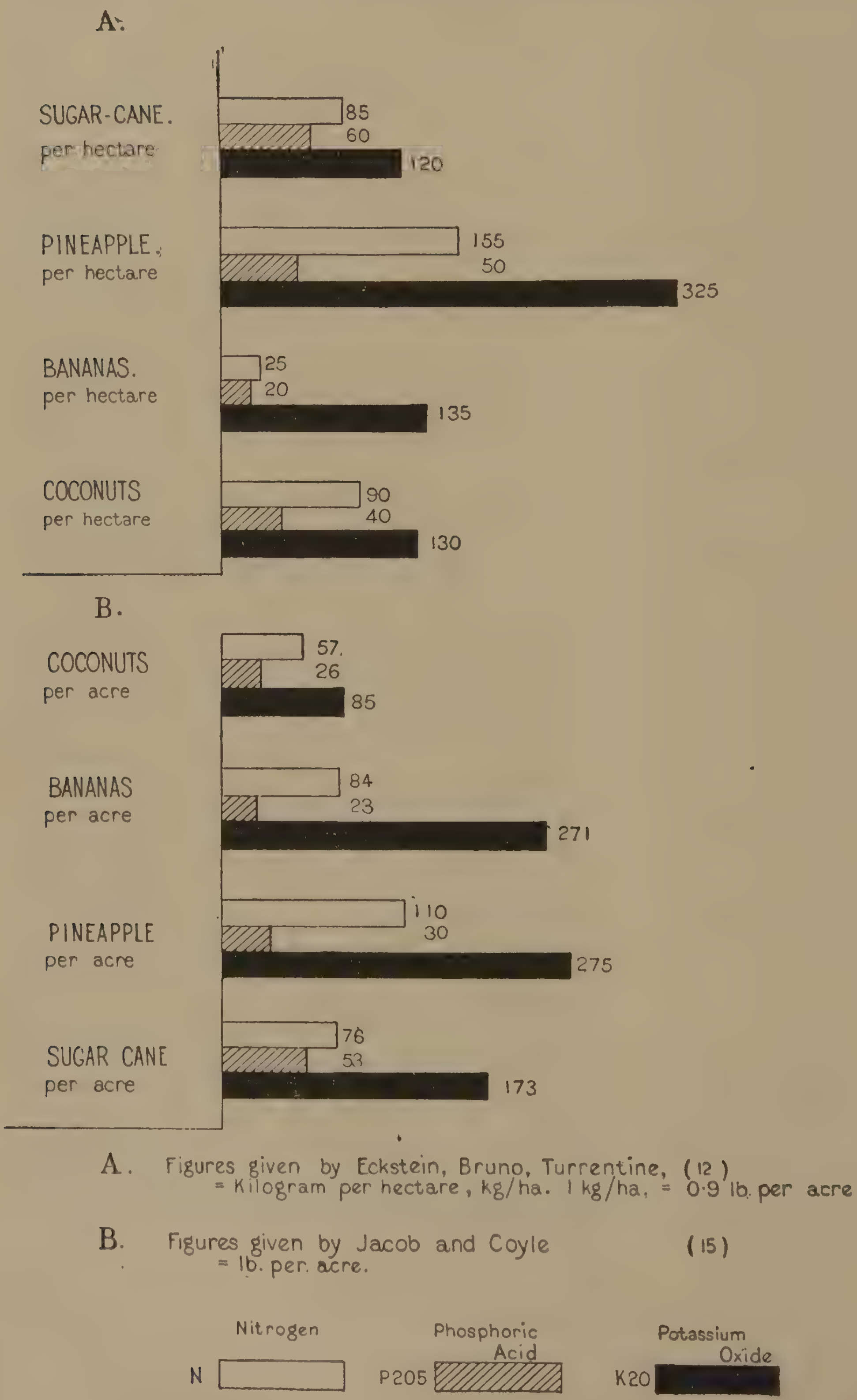
It has been pointed out that the worst manifestations of wilt in the West Indies occur where coco-nut planting follows sugar-cane culture. Reference to the graph, showing the approximate manurial requirements of this crop as compared with coco-nuts, will indicate that apart from the physical effects of this crop on the soil, sugar-cane has a much greater drain on the soil constituents than coco-nuts; this is particularly true of the potash requirements.

It will also be seen that this drain on manurial constituents (especially potash) is even greater in the case of bananas and pineapples, which are normally grown as native food crops in New Guinea. Cassava, taros, sweet potatoes, maize and other crops can be shown to have a similar effect. Some of the native non-leguminous creepers, commonly found in plantations, e.g. *Ipomoea robusta* (a very strong creeper of the sweet potato family), have a most exhausting effect on the soil. Such rampant-growing weeds as *Sida rhombifolia* and Blue Rat's Tail, *Stachytarphetum* spp., have much the same effect.

In ordinary native culture their normal shifting system of cultivation ensures that after one crop is sown it is a long interval before the same ground is utilized again. The exhausting effect of these native foods is thus recognized in a practical fashion.

In the past, and even up to the present time, it has been the practice of planters when developing new places here to grow large areas of native crops to feed their native labour or for sale. In numerous instances here, where plantations are just coming to the bearing stage, it has been possible to distinguish the palms growing

QUANTITIES OF PLANT FOOD REMOVED FROM SOIL BY TROPICAL PLANTS.



A. Figures given by Eckstein, Bruno, Turrentine, (12)
= Kilogram per hectare, kg/ha. 1 kg/ha. = 0·9 lb. per acre

B. Figures given by Jacob and Coyle (15)
= lb. per acre.

over old native gardens or on areas previously used for growing native crops. After growing such food crops, the soil is often left without cover for some time, so that the ground is exposed to the scorching effect of the sun's rays and to erosion and washing by heavy rains.

The young palms growing on such exhausted and previously exposed areas usually appear stunted with a general appearance of debility compared with the surrounding palms. The fronds appear yellowish or yellowish brown in appearance, as contrasted with the healthy green colour of palms growing on normal bush soils. It is rarely that these palms reach an extreme wilted appearance as is apparently common in other countries; nevertheless, this is probably a manifestation of the same kind of growth reaction but in a lesser degree. It is seldom that the palms do not recover when the palms get older and the roots get a greater hold on the soil. There are few plantations in New Guinea where some areas of palms showing similar symptoms to those indicated above do not exist.

It is unfortunate that one cannot present general chemical analyses of the common grasses found in New Guinea plantations. As far as this country is concerned, "kunai" or "lalang" grass, *Imperata arundinacea,* has all the deleterious effects of sugar-cane on the physical texture of the soil. This ubiquitous grass occurs over the whole Territory and its dense growth has a most exhausting effect on the soil. It has a deep matted and intertwined strong fibrous root system which goes down to considerable depths. Analysis shows that this grass has a high percentage of ash which is rich in potash. It is small wonder that palms growing in competition with such a growing and soil-exhausting grass fare badly and become more liable to both fungus and insect attack, besides reacting immediately to unfavorable water-table and climatic conditions. The relationship of the previous strong growth of kunai to the poor appearance of the palms coming into bearing at Kokopo (and probably in Namatanai) is readily understandable.

Coco-nuts Following Sisal Hemp: " Agave Sisalana ".

Near Constantinehafen, Astrolabe Bay area, there were formerly old sisal plantations, planted by an old German company. These were later abandoned and coco-nuts planted instead. As would be expected the coco-nuts did not thrive. Over large areas the palms remained stunted, yellowish and poorly bearing; often their tops fell off. About three-quarters of the whole area had to be abandoned. The main reason for this was the shallow stony soil present with deep layers of rubble underneath, allowing the water to get away quickly to the free underground water flowing through the gravels. The conditions were exaggerated by the impoverishing crops of sisal hemp previously grown.

Sisal hemp is a most exhausting crop, as is seen from the analysis quoted, and unless the waste is returned to the soil and heavy manuring carried out the soil may be rendered useless for other crops.

The green leaves of sisal contain in their ash 18.8 per cent. potash, 3.29 per cent. phosphoric acid, .098 per cent. nitrogen (low), 33.40 per cent. lime and 15.37 per cent. magnesia.

As would be expected the palms following such an exhausting crop showed marked signs of deficiency.

In addition to the shallowness and lack of nutrient content in this soil, the prevalence of leaf-droop and yellowing was largely caused by the previous cropping and the attempts to control weeds by burning off.

Curiously the predominant native grass which has now grown over the abandoned areas is a most rampant-growing, soil-exhausting species. The planters in the district usually refer to this area as a "kunai" or "kangaroo" grass plain. In reality, the tall coarse grass present is *Ophiurus megalophyllus,* a common species in the tropics which has no common name here. There are several other species present including the kangaroo grasses, but very little kunai. Based on experiences elsewhere, it is under these extreme conditions that die-backs would be expected in the coco-nut palms.

In addition to kunai and the small areas of true sugar-cane, grown for native requirements, the following indigenous grasses are listed as being amongst those which may produce similar bad effects on coco-nuts to those already indicated for kunai and sugar-cane:—

Saccharum spontaneum—Native sugar-canes.
Saccharum robustum—Native sugar-canes.
Chrysopogon aciculatus—Love or seedy grass.
Paspalum conjugatum—Thurston grass.
Themeda gigantea—Giant kangaroo grass.
Themeda australis—Kangaroo grass.
Ischaemum muticum—Swamp grass.
Sorghum nitida—Native sorghum.
Pennisetum macrostachymum—A native grass, very like elephant grass.
Ophiurus megalophyllus—A very strong vigorous grass, common in certain areas, e.g., at Melamu.

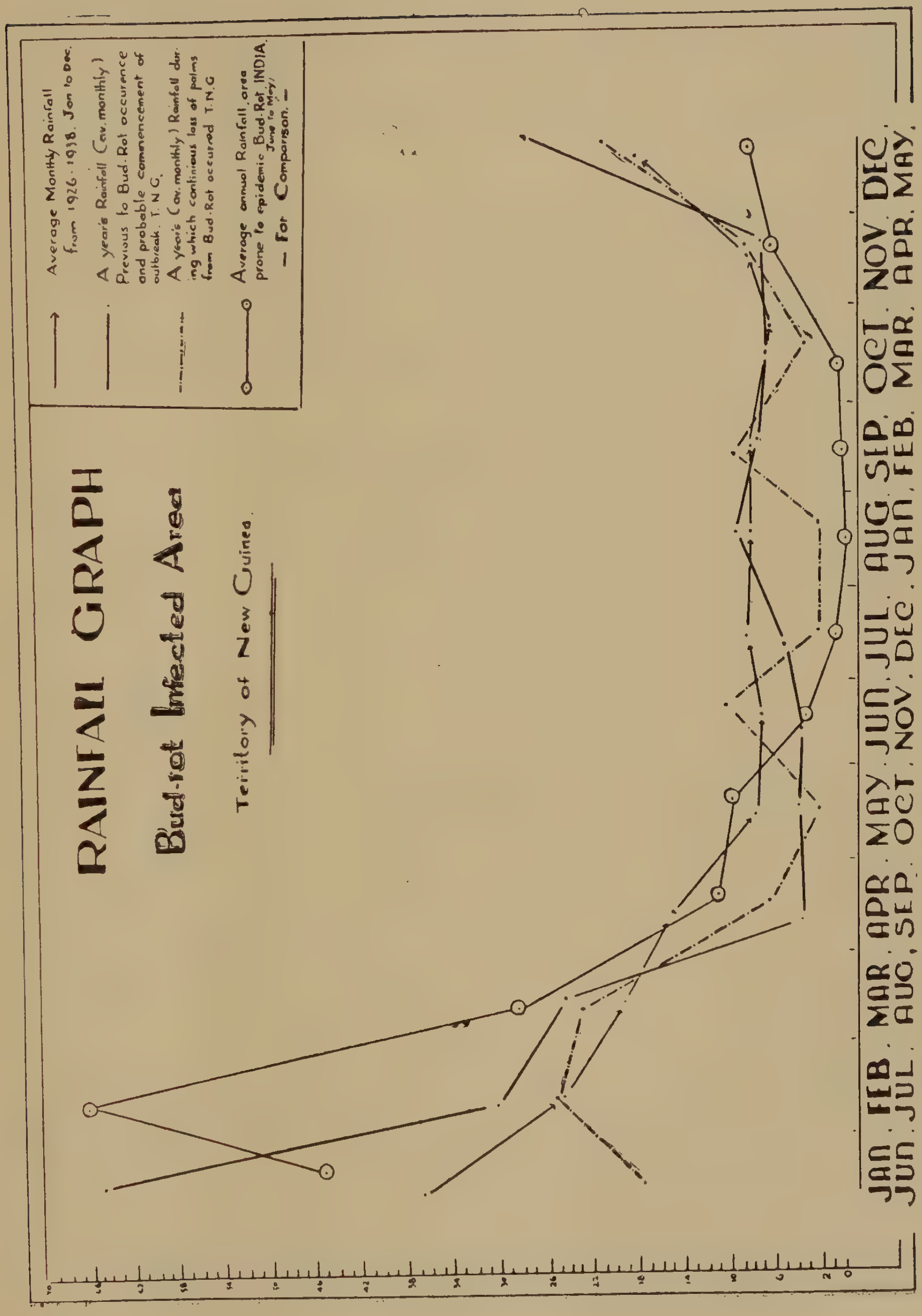
Tobacco.

On the Madang coast and in various other parts of New Guinea, coco-nuts have been planted after extensive trials of tobacco-growing had been carried out. Some of the biggest areas grown in German times were planted at Bogadjim (Stephansort, the first German capital of this Territory), where numerous Chinese were engaged in tobacco production. This may be one of the contributory reasons, apart from soil and climatic conditions, why the later planted coco-nut palms have not flourished.

In recent years tests have been made on growing tobacco leaf for manufacturing native twist or trade tobacco and coco-nut palms do not appear to flourish so well on areas used for this purpose.

SOIL CONDITIONS ASSOCIATED WITH BUD-ROT AND THEIR RELATION TO OTHER DISEASES

Association of unfavorable soil and climatic conditions with the development of true bud-rot, in which the fungus *Phytopthora palmivora* Butler was in evidence, have been recorded from certain New Guinea plantations. It is not intended that the sporadic occurrences of bud-rot be described in detail in this article. Certain contributory factors found in the situations where an outbreak occurred and which are of decided value in illustrating the conclusions of this present article are described. This is the first undeniable diagnosis of true *Phytopthora* bud-rot here and this was arrived at from investigations by the Director of the Department of a loss of several hundreds of palms. This fungus was at first definitely suspected from the macroscopic symptoms present (i.e., from


RAINFALL GRAPH
Bud-rot Infected Area
Territory of New Guinea.
Average Monthly Rainfall from 1926 - 1938. Jan to Dec.
A year's Rainfall (av. monthly) Previous to Bud-Rot occurence and probable commencement of outbreak. T. N. G.
A year's (av. monthly) Rainfall during which continious loss of palms from Bud-Rot occurred T. N. G
Average annual Rainfall, area prone to epidemic Bud-Rot, INDIA. June to May
— For Comparison. —
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY.
70
66
62
58
54
50
46
42
38
34
30
26
22
18
14
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6
2
0

the visible appearance and symptoms of the disease). This determination was backed up by the opinion of the Director of the Imperial Mycological Institute, based on the presence of fungus mycelium closely resembling *Phytopthora,* and from the descriptions and specimens forwarded to him. Unmistakable spore forms of *Phytopthora palmivora* were later isolated in Rabaul, from the tissue of a diseased coco-nut palm. In the future, a detailed article on the local occurrences of this disease will be presented.

The only losses of palms from bud-rot recorded here are from regions of heavy rainfall and usually occur under abnormal weather conditions. In the most recent records, it was noted that the first appearance of the disease coincided with a period when the rainfall was much wetter, in the wet season, and much drier, in the dry season, than was usual. This gives a much greater contrast of climatic conditions between the wet and the dry seasons (*see* graph). The loss of palms occurred on heavy soils under flat and foothill conditions. Significantly, it is under very similar circumstances that the scattered occurrences of bud-rot in Fiji have been recorded by Simmonds(26–27) and others.

The occurrences of this disease have been almost confined to the wetter portions of the Fiji group, being commonly found on the back portions of the estates, along the foothills. This comprises a region of continuous rainfall and frequently of poor drainage where the coco-nuts grow under unfavorable soil and climatic conditions which favour fungus development, but reduce the vigour of the palms. Palms growing close to the seashore with optimum water-table conditions are affected slightly as was found in the occurrences here.

The environmental conditions prevailing where bud-rot has been recorded here have many features in common with those obtaining where the other diseased conditions, described in this article, have been recorded, but are more extreme.

The heavy soils present are liable to water-logging in the wet season, and to drying-out and compaction in the dry season. This tendency is increased in areas of heavy rainfall and where poor drainage exists.

In a typical soil-profile of an affected area, it is found that there are proportionately large areas with very compact, almost impermeable hard-pan, or clay layers, present, which hold the water at the surface and restrict root-growth. In certain flat areas, where loss of palms, frond-fall and nut-fall were most in evidence, a stiff clay band was present, usually at a depth of 6 inches to 9 inches, but often almost to the surface. It is seen from water lying about in shallow depressions and from other signs that a superimposed water-table exists in the wet season which disappears in the dry season. The evaporation of this surface water continually adds to the humidity of the surrounding atmosphere.

Below the first clay zone there was, in several places, a sandy sub-soil layer present which was loose and porous and extended to a depth of at least 2 feet. Below this again a second impervious clay band is often met with, which is blue-grey in colour (showing the presence of un-oxidized iron) and represents a second zone where deposition of fine particles has taken place.

The root systems of coco-nut palms growing under these conditions are restricted by the relatively impervious layers near the surface, especially as the water stagnates there in the wet season.

Some root-growth does occur below the first clay layer, but is absolutely prevented where a second clay layer or other hard-pan exists.

In the dry season the loose sand, underneath the clay, is believed to reduce the water supply to the palms, which effect would be greatly increased in the dry season. The clay layers present hinder water movements and the access of the roots to the true water-table. It is obvious, without reference to the bud-rotting and other organisms present, that such conditions are not optimum for the growth of coco-nut palms, though they do favour most types of fungus development. The *Phytophora* bud-rot disease particularly can only be exceedingly destructive in a very moist atmosphere.

Where bud-rotted palms are found on the sides of low foothills, the water-table may not be so close to the surfaces, but the soil conditions may still lead to water-logging and restricted root-growth. On one typical area it was seen that the surface soil was a stiff chocolate clay loam, which was stiffer even than those soils found on the flats. The sub-soil was an extremely fine-grained and puggy clay, resting on a compacted layer of weathered parent basaltic rock. This weathered rock formation gradually merges into the unweathered parent rock at a comparatively shallow depth. The soil as described is very puggy in the wet season but sets like a brick in the dry season. Palms growing under these conditions do not flourish. This can be seen from the chlorotic leaves, reduced length and number of fronds, and the grass ground covers present showing a light overhead canopy. It is impossible to think that such climatic conditions, and soil and water-table formations, do not have a great deal to do with the development of bud-rot. Obviously, it is no coincidence that the type of bud-rot found here, and in Fiji, occurs under such conditions.

In the Philippine Islands bud-rot only assumes epidemic proportions in one of the most humid districts of the islands, where the soils are heavy and wet.

The late Dr. Sharples,(25) in 1924, enumerated several instances of where investigators had recorded outbreaks of bud-rot in various parts of the world which were associated with unfavorable soil and climatic conditions. It was resolved at the Imperial Botanical Conference of 1924(25) that the term "coco-nut wilt" be applied to such occurrences as were falsely designated bud-rot, for the reason that the bud, as a general rule, was the last portion of the crown to become affected.

It is the author's opinion that, whether the crown is affected first (as in the instances of true bud-rot given) or last, the soil conditions always warrant very close study wherever outbreaks of wilts and bud-rot occur.

It has been mentioned right throughout this article, that there are several other diseases and conditions of the palm influenced by related environmental conditions. In this regard, it is a significant fact that on some areas where true bud-rot was recorded here, the following series of diseases or symptoms were noted. Leaf-droop, leaf-break, nut-fall (bad), frond-fall (bad), leaf scorch, deficiency spotting, taper stem, *chlorosis*, stem bleeding, *Pestalozzia*, leaf-spotting, thread-blight (*Corticium penicillatum*), *Botryo-diplodia theobromæ* and a condition tentatively named "gummy leaf". It is plain that many of these conditions (especially the first nine listed) are symptomatic of the particular soil conditions prevailing, rather than distinctive diseases.

It is worthy of note that the dynastid beetles (especially *Xylotrupes gideon*) had caused considerable damage under these conditions and probably favoured the spread of the disease.

There may be a number of inter-related and inter-acting factors (working both from within and outside the palm) responsible for palms showing a series of pathological derangements such as those described.

It is very clear from the considerations outlined that cultural practices designed to keep up the vigour of the palms and remedy unfavorable environmental circumstances are of the utmost importance in disease control.

Discussion.

It is necessary to refer to the well-known subject of optima and limiting factors to obtain a true idea of what occurs where there are a number of inter-acting conditions of nutrition and environment necessary for best growth of the palms. Optimum growth is impossible wherever one main limiting factor is present, as this will determine the maximum influence of any other factors present. In plant growth, there is no such thing as the influence of one factor without reference to the effect of other conditions present. It has been shown that water supply and available potash are two of the very important factors limiting the growth of coco-nut palms. Besides acting as simple, limiting factors, they also interact in many ways, as is indicated in various sections of this article. Regardless of the amount of potash present in the soil, only a certain total quantity can be absorbed by the palm if the water supply is checked in any way.

It is, however, reasonable to state that where the water and potash contents of a soil are both too low (or too high) much greater detrimental effects of malnutrition can be expected. Looking at this contention in another way, let us assume that by a series of pot culture or other methods, it is possible to maintain an optimum water supply to young palms all growing in a constant nutrient medium and to vary the potash supplied to them. Then some plants will be found to have lower than the minimum supply of potash necessary for the proper growth of the palms, so that pathological symptoms may result. Some palms will show lesser effects of the deficiency by being only a darker green than others then, within a certain range, other palms will appear quite normal. Other palms, with so much potash supplied as to upset the balance with the other nutrients and moisture present, will either show no increase in growth or else retarded growth.

If the supply was varied in another series of similar cultures, and the potash kept constant, then similar variations in growth responses would be expected. If both the potash and water supply to the palms was varied, it is likely that the palms receiving the larger quantities of water could do with less potash within certain limits. This is an attempt, in a simple way, to demonstrate how limiting factors may work and also indicate one type of experiment necessary to determine the nutrient requirements of coco-nut palms. Obviously, such pot culture experiments are relatively simple with annual plants, such as the tomato, but are difficult with long-lived and bulky perennial plants like the coco-nut palm. It might be mentioned here that annual plants, like the tomato, have been used as indicators as to the nutrient requirements of other plants, in pot experiments.

The subject is very much more complex, however, than is indicated here, when it is considered that such nutrients as nitrogen, phosphates, calcium, &c., all have their effect and that temperature and actual inherent vigour of the plant come into play.

It must also be recognized that the coco-nut palm has very great inherent capabilities of adapting itself to its environment and to varying conditions of moisture and nutrient supply. Sampson(24) and others have indicated that a coco-nut palm shows a much different analysis when grown on a good soil than on poor soil, which means that the plant can and does economize on plant food under unfavorable conditions.

It might be pointed out that there is a growing mass of evidence to prove that when the humus content of the soil is allowed to run down below a certain level, crops become increasingly subject to diseases of all kinds.

It must be stressed that the inter-action of many limiting factors has to be considered when investigating any physiological disease. The genetical constitution of the plant usually interacts with environment and it is found that weaker palms are much more affected by unfavorable soil and water relationships than strong ones.

One would think that when wilting of palms actually occurred, the end point of water or nutrient deficiency was not far away and that there may be several degrees of growth differences between this and a normal palm.

Thus, although palms do not show pronounced deficiency symptoms, they may have their vigour sufficiently reduced to render them liable to fungus attack. Though there are relatively few records of occurrences of severe palm wilts in New Guinea approaching those known as "bronze wilt" in the West Indies, how are we to classify the occurrences which are recorded here? Is the "maturation wilt" described to be classed in the same category as the more permanent "mature palm wilts", such as are described from the Madang coast? It seems that much more detailed work is necessary as regards the actual physiology and nutrition of the coco-nuts, through all stages, before complete understanding of the problems is possible.

It is no coincidence that similar unsuitable soils conditions to those described as causing coco-nut wilts elsewhere, are responsible for similar physiological diseases here. There appears to be a tendency to classify all pathological symptoms due to soil moisture and deficiency relationships as wilts. One should remember that complications are frequent where otherwise harmless organisms attack the plant, once its vigour is lowered. Wilts, bud-rot, nut-fall, leaf-droop and many other diseases are all symptoms which may be due to different causes, but it has been shown that they may be closely inter-related under certain conditions.

As mentioned before, it is probable that wilts are, as yet, not so prevalent in New Guinea, because the soils are newer and, secondly, because the land has not been cleared of its virgin jungle and been in cultivation with soil exhausting crops for so long.

In addition to major nutrient deficiencies, several unfavorable circumstances are listed. These may, or may not, be present, but where found could be expected to produce outward visible symptoms in the growth of the palms, especially if several were found together in the one situation—

1. Stiff soils or soils too porous.
2. Class of subsoil and the presence of hard pans and superimposed water tables.

3. Shallow planting.
4. Poor seed nuts (inherent vigour of the palms).
5. Previous cropping with exhausting crops.
6. Presence of grasses and weeds.
7. Close planting.
8. Overshading.
9. Continuous burning off.
10. Exposure to heavy winds.
11. Excessive rainfall and continuous cloudy weather.
12. Drought.
13. Season of coming into bearing.
14. Cultural conditions, such as lack of cultivation or drainage.
15. Overstocking the plantation with cattle, especially where tramping over heavy soils.
16. Leaching and erosion of the soil.

If deficiencies of other minerals (e.g., rare metals) are involved in some New Guinea soils, as well as any major nutrient deficiencies, the palms would undoubtedly show other distinguishing symptoms. Theoretically, different combinations of limiting factors may lead to distinct types of physiological diseases.

Finally, it is necessary to decide where one is dealing with physiological wilts or with virus diseases caused by ultra-microscopic viruses carried by certain vectors such as sucking insects.

The influences of water relationships and nutrition on fruit setting, nut-fall and disease occurrence in coco-nut palms, show how closely related are soil problems (physico-chemical) and the functions of the plant (physiology). It is also shown how necessary it is to associate chemical findings with botanical studies and considerations. The determinations of the virus and other diseases present are the province of the plant pathologist.

It would be a most valuable contribution from physiological and chemical research to find out, in detail, whether there is a heavy drain on any particular elements, when the palms are reaching the bearing stage and just what changes do occur.

It is the sphere of the chemist to give us much more data on the nutrient status of the soils here, and to give us detailed chemical analyses of the plant itself. The future studies of our departmental chemist are expected to elucidate many of the problems outlined in this article.

Remedial Measures.

A description of the correct agricultural practices in coco-nut cultivation would entail a separate article, hence some of the salient points only are indicated for New Guinea conditions in particular. It is necessary to consider most of the conditions which affect the nutrition and health of the coco-nut palms in determining any suitable methods of prevention or control of coco-nut wilts, or similar physiological diseases. References to suitable measures for control of maturation wilts have been made as the particular conditions were described.

The selection of the original plantation site is most important. When selecting areas for coco-nut planting avoid obviously unsuitable soils and situations by making preliminary soil surveys. Proper attention should be paid to the nature of the sub-soils present. This can be determined by digging deep holes at specified intervals and also studying the soil profiles in exposed banks of creeks, cuttings, quarries, &c., before the planting is proceeded with. Soils liable to water-logging, such as in low-lying, swampy areas, should not be planted, nor should those areas with hard-pans or wide stony layers present in the sub-soil strata.

Naturally unsuitable formations such as hard-pans, solid rock too close to the surface, clay belts and similar unfavorable profiles are usually unchangeable circumstances once the palms are planted. If coco-nut wilts occur when the soils have an impervious hard-pan the condition is irremediable. Proper clearing and planting methods must be followed and it is necesary for the best growth of palms that planting at the right depths, in well prepared holes, be carried out.

Seed and nursery selection are most important procedures rarely followed in this country though commonly urged by this department.

Where it is necessary to plant coco-nuts in wet situations drainage is essential. Deep main drains following a proper fall should be constructed with plenty of smaller lateral drains leading into them. Levels should be taken with a dumpy level, row tracer, or suitable contrivance before the drains are made.

Cattle grazing over wet soils liable to compaction are injurious to the growth of coco-nut palms on such soils. It is not possible to drain soils when they are running in the plantation. They may be beneficial when rotationally grazed in properly sub-divided paddocks where the soils are friable and free working.

Strong growing grasses and other exhausting plants should not be allowed to take possession of the planted areas. Eradicate "kunai", or "lalang", *imperata arundinacea,* also seedy grass, *chrysopogon aciculatus,* particularly. Nothing does this better than where the palms are vigorous growing and provide a dense, overhead canopy, as grasses generally do not flourish under dense shade.

Do not grow soil-exhausting crops such as sugar-cane, bananas and native food crops prior to planting out coco-nuts unless a suitable rotation is used. The graphs showing the high manurial requirements of heavy feeding crops well illustrate the reasons for this. There is legislation in force in Malaya to prevent more than one crop of such plants as cassava, *manihot utilissima,* being grown prior to planting of permanent crops such as rubber.

The use of drier ash, composted refuse, &c., and the provision of complete chemical fertilizers and potash manures to increase the vigour of the palms and remedy deficiencies are indicated. There are economic and other considerations involved which require detailing in a separate study. The use of burnt coral and slaked lime is worthy of much greater trial on some of the stiffer soils in this country.

One of the most important problems on New Guinea plantations is the conservation of humus and organic matter which is very seldom given sufficient attention.

The effects of continuous burning off on the humus supply of most tropical soils is disastrous in the long run. Of course, where pests are bad, occasional burning off of accumulated rubbish is essential. Burning off is usually practised to try and kill off injurious growths and to revive the vigour of palms which should never have been allowed to get into such a state of decline.

The conservation of the humus involves various methods of assisting the dropped fronds, cut weeds and husks to decay without actually being lost from the soil.

Cultivation, ploughing, mulching, circle weeding, hoeing, rolling of dense covers, &c., are all subjects which need separate discourse. It is apparent that clean weeding, hoeing or ploughing should not be carried out in the middle of the dry season, or in times of drought, especially in shallow soils, where the fibrous roots are close to the surface. The palms may suffer badly and show wilting where the water and nutrient supplies to the palm are reduced by the cutting of these roots under such circumstances.

The uses of creeping covers on plantations have already been dealt with in an article by the Director.(34)

In soils greatly depleted of humus, the use of erect, cover crops such as *Leucaena glauca, Tephrosia candida* and *Crotalaria anagyroides*, is recommended. These are cut back at intervals and, if possible, the final objective should be to establish suitable creeping cover crops under them.

Among the great uses of cover crops is that they keep the soils cold and moist over the dry season, reduce severe fluctuations in soil moisture and thus greatly lessen the necessity for root adjustment.

On heavy soils, cover-cropping is recommended providing drainage is adequate. Under wet soil conditions less rampant growers like *Desmodium scorpiurus* or *Dolichos hoseii* are worthy of trial. Cover crops should be kept under control and slashing, hoeing or turning under the rampant cover periodically, say, once in every twelve months or two years, adds humus to the palms and increases their vigour. Where the palms are poorly vigorous circle weeding should be carried on where cover crops are used, as root competition may occur under such circumstances.

This Department recommends *Centrosema pubescens, Pueraria javanica* and *Calopogonium mucunoides* for normal coco-nut soils. It must be remembered that these covers show a high percentage of mineral nutrients on analysis which are returning to the soil in an available form when they are cut back or the leaves drop naturally. They also possess the faculty of adding nitrogen to the soil per medium of the bacterial nodules on the roots. Cost of plantation maintenance and weeding are greatly reduced where cover crops are established.

Phenomenal yield increases are the result often expected from the use of cover crops which are not realized in practice for various reasons which it is not possible to describe here. It is certain that if the plantations in this country had been cover-cropped ten years ago, and proper cultural practices followed, many of the older plantations here would not be approaching the stage of uneconomic production as is the case to-day. Increased yields per acre lessen cost of production and care and attention to the planted areas are usually repaid by the additions to the economic life of the property.

Obviously, the natural rainfall and climatic conditions cannot be changed and the soil profiles are also constant. It is usually possible to improve the vigour of coco-nut palms by methods which prevent water-logging, increase the available depth of soil and the water and nutrient supplies available to the palms. The profound importance of employing proper cultural methods for control and prevention of coco-nut diseases is consequently indicated.

Summary.

An account of some further investigations and observations on occurrences of physiological disorders (wilts, die-backs, &c.) of coco-nut palms in New Guinea is presented.

Special attention is paid to "maturation wilts" of young coco-nut palms at the first bearing stage, recorded from various parts of this Territory.

The symptoms and pathology of the disease at Namatanai, New Ireland, and, also, the detailed investigations and identification of the organisms present by the Director of the Imperial Mycological Institute are given. His comments relating this occurrence to the "cadang cadang" disease of the Philippines, made it necessary to consider the possibility of virus causation.

Reports on soil analyses by the Waite Institute and the comments of their Chemist and Plant Pathologist on the nutrient status and water-relationships of the soils, associated with the occurrences at Kokopo and Namatanai are presented. They indicate the close resemblance between these occurrences and the "bronze wilt" described from Trinidad.

The evidence presented shows that this "maturation wilt" is most probably a physiological disease. During three years, the symptoms made a cyclic appearance in dry periods, and each time disappeared when the conditions became favorable.

Some pathological derangements of mature palms ("mature palm wilts"), particularly from those plantations situated on the deltaic and estuarine deposits of the Huon Gulf and Astrolabe Bay areas of the New Guinea mainland, are described, as are the contributory causes.

Most plantations in this Territory contain areas where palms grow poorly, nevertheless, severe coco-nut wilts are of relatively infrequent occurrence here, probably owing to special local conditions which are discussed.

The occurrences in New Guinea are compared with similar diseases recorded from other countries. These are "cadang cadang" disease, described from the Philippines as a suggested virus disease, "bronze wilts" from Trinidad and Jamaica, coco-nut wilts from Ceylon and derangements of palms coming into bearing described from Malaya.

The pathological symptoms displayed are of physiological origin, excluding possible virus diseases.

The chemical and physiological changes (especially as regards moisture requirements and potash movements) which occur in coco-nut palms at various stages of growth are discussed in relation to the diseases described. Particular attention is paid to the physiology of the root system and its natural adaptations and reactions to such unfavorable circumstances as water-logging and lack of aeration.

Several other diseases and derangements of coco-nut palms present in this country are described (*see* also previous article(9)) as being primarily associated with similar unfavorable soil, moisture, and nutritional relationships to those already mentioned, though the symptoms displayed are often complicated by fungus and insect attack. "Seasonal bearing", "leaf-droop", "frond-choke", certain types of nut-fall, "bud-collapse", "deficiency spotting" and "die-back" appear to belong to this category.

Selected soil profiles showing unsuitable soil, sub-soil, water-table and moisture relationships are described, both in relation to diseases present and their control.

The importance of proper cultural conditions in relation to the control of most coco-nut diseases, but particularly those of physiological origin, is stressed.

The relative importance of physiological disorders of coco-nut palms as related to fungus diseases, or distinct from virus diseases, is not yet determined. The necessity for chemical and botanical research on the nutrition of the coco-nut palm in relation to the soil conditions obtaining here is clearly indicated.

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The soil analyses published in connexion with the investigations on maturation wilts were carried out through the kind courtesy of Professor Prescott, Director of the Waite Institute, South Australia.

The analyses were made by J. H. Hosking, Soil Chemist, who has since published an article(32) which includes a detailed comparison of the soils from Kokopo with the deposits from the Rabaul volcanic eruption of 1937. His comments and those of D. B. Adam, Plant Pathologist at the Waite Institute, in connexion with the occurrences described, are most valuable and gratefully acknowledged.

F. Henderson, Inspector and Instructor of the Department of Agriculture, New Guinea, carried out useful collaborative work on the disease in New Ireland, being detailed for this work by the Director.

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CONTROL OF COCO-NUT TREEHOPPERS (*SEXAVA* SPP.) BY DUSTING.

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During the year 1937, a number of laboratory experiments were made to test roughly the comparative toxicity of various dusts to the coco-nut treehopper, *Sexava* spp. These dusts included calcium arsenate, lead arsenate and paris green —diluted in each case with hydrated lime—as well as mixtures of derris, and proprietary mixtures which had as lethal constituents lead arsenate, nicotine sulphate, derris and orthodichlorbenzene. The dusts were applied at a rate somewhat greater than would be economical in the field, the object of the experiments being merely to eliminate the obviously inefficient and uneconomical preparations. Those which appeared most effective were to be tried later in field experiments, using a power dusting machine.

The experiments were carried out as follows:—

Cages of copper wire, 3 feet high and 2 feet in diameter, were constructed, and in each of these from 30 to 50 adult treehoppers were placed, together with food consisting of coco-nut palm leaflets strung on a wire passing across the top of the cage. A hand-duster was used to apply the various dusts, and in each experiment one cage was left untreated, to act as a control. After the first day, fresh, undusted leaflets were placed daily in the cage, the original leaflets being removed. The effectiveness of the treatments was measured by the percentage of treehoppers killed within three days after dusting.

These tests showed that the arsenicals, paris green, calcium arsenate and lead arsenate, were by far the most efficient of the dusts. Paris green was easily the best, but its price appeared prohibitive, and this fact, together with the danger of foliage-burning, caused this insecticide to be passed over in the earlier field trials, though later it was tested out.

Calcium arsenate and lead arsenate appeared roughly equal in toxicity, but as the former was the cheaper, it was the first to be tried in field experiments.

A few results, typical of those obtained in the laboratory tests, are appended. The figures given are the percentage of deaths within three days of treatment—

	Per cent.
Control	10
5 per cent. lead arsenate	97
5 per cent. calcium arsenate	97
5 per cent. paris green	100
Control	10
Proprietary mixture of lead arsenate	100
10 per cent. derris	47
Proprietary mixture of derris	77
Control	16
5 per cent. lead arsenate	100
Proprietary mixture of derris	40
Derris 2½ per cent., orthodichlorbenzene 2½ per cent.	40

The paris green in each case killed about 90 per cent. of the insects in one day, and invariably during the second day all were dead. An interesting point was that the insects did no feeding in any of the cages where paris green was used, showing that death was caused most probably by their ingesting particles of the dust during the process of cleaning their feet and antennae. The effects of the dust must have been very rapid, as dusting was carried out always at about 4 p.m., and yet the treehoppers had lost the desire for food by 6 p.m., when feeding normally begins.

Lead arsenate and calcium arsenate also cause death when ingested during the process of cleaning. For this reason the cages had to be very thoroughly washed after each experiment, as any particles of dust remaining on the wire would affect subsequent tests. On one occasion, cages which had been used for tests with the three arsenical dusts were washed roughly, and treehoppers were placed in them with fresh food, no dust being applied. After three days, the majority of the hoppers were dead, showing that even the traces of poison left on the wire had been sufficient to provide a lethal dose. Percentage mortality in the various cages was as follows:—

	Per cent.
Control	18
Traces of 5 per cent. lead arsenate	88
Traces of 5 per cent. calcium arsenate	70
Traces of 5 per cent. paris green	80

An experiment was carried out also to assess the burning effect of paris green on coco-nut palm foliage, a brief description of which follows: A six months' old potted palm was dusted very heavily with 10 per cent. paris green in hydrated lime, the leaves being first moistened to assist adhesion of the dust. For twelve days the palm was left in the open, but removed to shelter when rain fell, so that the dust would not be washed off. After the lapse of twelve days, it was left permanently in the open. At the end of three weeks, small, scattered, brown patches were noticed on the leaflets, and after six weeks the burnt areas were fairly extensive. This was, of course, a very severe test, and it is doubtful if burning occurs when paris green is used in the field, as the rate of application is much lower, and the dust is washed off by frequent rains. Calcium arsenate, when similarly tested, caused no burning.

Field Experiments.

During the period May to November, 1938, a power duster was used in the conducting of field experiments, the object being to determine the cheapest and most efficient type of dust and rate of application which would achieve reasonable control of the treehopper. In the earlier experiments calcium arsenate was used, and later, lead arsenate and paris green were given a trial. Paris green can perhaps compete economically with calcium arsenate, but lead arsenate, besides being more expensive than calcium arsenate, proved to be much less effective. It was found that diluents could be dispensed with in the case of calcium arsenate, as good coverage of the foliage could be achieved with the undiluted dust. With paris green, however, a filler is necessary, as the rate of application per acre is so low that the undiluted dust would not give even coverage. Hydrated lime was generally used, though trials were made of kaolin and proprietary fillers to determine whether they improved the adhesion of the dust to the foliage. It cannot be said that they were successful, so there is no point in using them except as a diluent. This line of inquiry is not closed, however; it is hoped that a good sticker may be found, thus considerably increasing the effectiveness of dusting as a control measure.

The result aimed at in the field tests was that there should be a mortality of 90 per cent. or more of the pests, when dusting was followed by only one night without rain. Hence, particular attention was paid to the results of experiments in which rain fell after the insects had fed for one night only on dusted foliage, and estimated costs of treatment were based on these results. As the treehoppers feed almost exclusively at night, it is obvious that a fall of rain before their first nightly feed would greatly reduce or neutralize the effect of the treatment, as the dust is easily washed off by rain. This proved, in fact, to be the case. On the other hand, where several rainless days and nights follow on dusting, deaths are more numerous, and where such weather can be counted on, the costs tabulated below can be materially reduced by decreasing the rate of application of the dust.

Unfortunately, owing to the smoothness of the leaf-surface of the palm-foliage, dust will not adhere well to the under surface of the leaflets, where it would be sheltered from the rain.

It seems opportune at this juncture to explain why dusting was decided on instead of spraying. The latter method calls for the use of a smaller quantity of poison, and has the great advantage of causing the spray material to adhere to the leaf surface, even during periods of heavy rain, provided that the film of spray material has had time to dry before rain falls. However, conditions on a local coco-nut plantation make the use of sprays quite impracticable, except in some cases on low palms. Because the spray has to be applied to foliage 50 to 60 feet from the ground, and applied thoroughly, in the form of a mist, a powerful and heavy spraying machine would be necessary to treat an affected area in a reasonable time. The difficulties of operating such a machine in a plantation need no stressing. Large quantities of water would be required (about 200 gallons per acre for each spraying) and the mixing and transporting of the spray material from a depot to all parts of the plantation would be a very big task. Moreover, the time taken for treatment would be several times that taken in dusting. Hence it is clear that spraying is not suitable for local coco-nut plantations.

Dusting, on the other hand, is a comparatively simple process, as a light and low-powered machine, which can be carried by natives or drawn on wheels, will treat 10 acres of palms per hour. Further investigation of dusting machine types is required to determine that most satisfactory for plantation conditions in this Territory.

Technique of Experiments.

For each experiment, a block of 64 palms (1 1/7th acres) was selected, having eight palms on each side. Each block of palms was well separated from the others, so that dust could not drift from one to the other during treatment. Then the fronds were cut from a palm in the middle of the plot, normal in height, foliage and extent of attack by *Sexava*, and the treehoppers counted. The plot was then dusted, and after seven or eight days a similar palm was defoliated, and the remaining *Sexava* counted. Difference in the two counts was taken as the mortality. This figure would naturally be only approximately correct, but satisfactory, as palms in a given locality seem always to have much the same population, and inaccuracies are reduced by comparing the results of a number of experiments. Cutting of fronds and counting of treehoppers thereon, incidentally, is the only really satisfactory way of determining the severity of *Sexava* attack on a plantation. The appearance of the fronds is no guide, as badly chewed palms may have few treehoppers, but show the effects of previous severe attacks, while healthy-looking palms may harbour large numbers of the pests, constituting the vanguard of a heavy infestation. Collecting of adults at night is a good guide to the most severely-affected portions of a plantation.

When the population of a palm is being determined, a native is sent aloft with a bush knife or hacksaw and a long rope. He cuts off the fronds, and lowers them one by one onto a sail spread at the foot of the palm. Here they are examined by several natives, under supervision, and the treehoppers caught and counted. During the day they are almost invariably found on the under-surface of the leaflets, and careful scrutiny is necessary to find them all, particularly the young nymphs. Examination of a palm by this method takes from one to three hours, depending largely on the efficiency of the boy who cuts and lowers the fronds.

To prove that the insects were killed by the dust, and did not merely migrate elsewhere, large sheets of bagging were placed under certain dusted palms, and on these numbers of dead *Sexava* were found during the few days following on dusting, their condition showing that they had been poisoned.

In almost every case, dusting was carried out between 4 p.m. and sundown, because at that time of the day, it was possible to forecast fairly well whether rain would fall overnight or not. As regards wind, a steady air-drift or light breeze is desirable, at it carries the dust steadily in one direction. When the direction of the air current is changing rapidly, dispersal of the dust is unsatisfactory. This is especially so when two or three rows of palms at a time are being dusted. It appears that successful dusting can be carried out even with quite a strong breeze, as results obtained under these conditions have been good, even though most of the dust appears to be swept away underneath the foliage of the palms. At present, it appears that the most satisfactory combination of speed and efficiency can be achieved by treating two rows of palms at a time. This makes possible the dusting of about 10 acres per hour, except in unusually rough country.

In all, over 30 experiments were carried out on small plots, and two 10-acre plots were also treated. On the large plots it was intended to carry out the full programme of two dustings at an interval of about 100 days. Consequently, they had to be reasonably large, so that results would not be unduly affected by immigration of *Sexava* from surrounding untreated areas, during the six or twelve months needed to show the effects of the treatment on yield and health of palms. Two dustings will almost invariably be needed to achieve reasonable control of the treehopper, the first dusting being designed to kill those already on the palms, and the second to deal with those which have hatched out after the first dusting. The interval of 100 days allows time for the most recently laid eggs to hatch, but not for the earliest hatchings to reach the adult stage and lay a further batch of eggs.

It is extremely difficult to present the results of the experiments in a concise form, so that it has been thought better to give those of some typical successful experiments. These will give a good idea of the killing capacity of the dusts used:—

1. 11½ lb. of undiluted calcium arsenate per acre.
   Dusted three rows at a time.
   One night only without rain.
   Population before dusting—98 (36 adults, 62 nymphs).
   Population after dusting—1st row nil, mortality 100 per cent.; 2nd row nil, mortality 100 per cent.; 3rd row 2 adults, mortality 98 per cent.
2. 8 lb. calcium arsenate per acre, diluted with 9 lb. lime.
   Dusted two rows at a time.
   Three nights without rain.
   Population before dusting—75 (18 adults, 57 nymphs).
   Population after dusting—1st row nil, mortality 100 per cent.; 2nd row nil, mortality 100 per cent.
3. 3 lb. paris green per acre, with 21 lb. lime.
   Dusted two rows at a time.
   Five nights without rain.
   Population before dusting—105 (27 adults, 78 nymphs).
   Population after dusting—1st row 4 nymphs, mortality 96 per cent.; 2nd row 4 nymphs, mortality 96 per cent.

Paris green has not been tried as thoroughly as calcium arsenate, but, at present, it appears that the latter gives somewhat better results on a cost basis, and it has the advantage that it does not need the addition of a filler such as hydrated lime to make it of sufficient bulk to give a good cover of the foliage. A filler is necessary with paris green, which is very heavy, and mixing entails extra time and labour. There is also some evidence that calcium arsenate has a delayed action, causing deaths weeks after being eaten by the insects, but this needs further investigation. The cost of material for two dustings with calcium arsenate at a rate of 12 lb. per acre is about 9s., and the same expenditure would allow of two dustings with 3⅓ lb. paris green and 9 lb. lime. All costs, except for hydrated lime, are based on pre-war American quotes, as prices of arsenicals in Australia are prohibitive. Moreover, the calcium arsenate from the United States of America has proved superior to the Australian article. Manufacture of commercial calcium arsenate in the United States of America has reached a high pitch of efficiency, owing to the vast quantities used annually in the control of pests like cotton boll weevil.

It is anticipated that the total costs of dusting an acre of palms twice will not exceed 11s., including cost of material, depreciation on machine, oil and fuel, labour and supervision. On some properties, where treehopper attack is consistently extensive, it would seem economical to treat the whole plantation first, and during the succeeding years promptly treat any local outbreaks, so that the pest never regains a hold. Complete eradication by artificial means is scarcely possible, and an attempt would be extremely costly, so that the object to be aimed at should be reasonable control.

The economics of the subject are, of course, of paramount importance, for, where dusting might show a profit with copra at £10 per ton on the beach, it might not be profitable at the £5 mark. At the latter price level, only the heaviest losers from *Sexava* attack might find it worth while to conduct a dusting campaign. In this connexion, the following calculations may be of interest.

A plantation known to the writer is 600 acres in area, and has been severely attacked by *Sexava* for a number of years, production at times falling as low as 6 tons of copra per month. When this property was taken over from the Expropriation Board, its average monthly production over a period of years had been 32 tons. For the five years 1933 to 1937 inclusive, the average has been 16 tons. This may not be due solely to the activities of the treehopper, but the many severe attacks by the pest have undoubtedly been the major factor in the decrease.

The cost of two complete dustings of this plantation at 11s. per acre amounts to £330, so a reasonable estimate to cover unforeseen eventualities would be £400. Probably, during the remainder of a five years' dusting campaign, it would be necessary to dust only isolated areas, as signs of renewed infestation appeared. Two dustings of 100 acres in each of the five years would seem a generous estimate, though only experience will show what is actually necessary. These dustings, at 11s. per acre, would cost £275, so one might budget for £350, making the total cost for five years' control of *Sexava* £750.

In assessing the gain due to increased copra production, it must be remembered that the price received for the extra copra is nearly all clear profit, apart from the cost of dusting, because the increased output is achieved without an increase in capital charges. Bags and twine must be allowed for, and possibly some increase in labour strength, the cost of which items, estimated at £1 10s. per ton, must be deducted from the beach price of copra. At the time of writing, the latter is about £6 10s. per ton, so that each extra ton of copra produced as a result of dusting represents a profit of £5. Hence, to pay for the cost of the dusting campaign, plus interest on the £750, about 170 tons of extra production would be needed during the five years, that is, a little less than 3 tons per month. Any increased production over and above this would represent clear profit due to dusting, apart from the long-range effect of protecting the palms from injury. If copra were only £5 per ton during the five years, 4½ tons per month of extra production would be needed to cover the cost of dusting, and, if it were £10 per ton, a little over 1½ tons extra would be required.

In the case of the plantation mentioned, it is obvious that everything points to a large increase in revenue as a result of a dusting campaign. A calculation along these lines should indicate to any planter whether it would be worth while to embark on such a venture. In the case of less severely infested plantations, dusting of the whole area at one time might not be economical or necessary, the main principle in successful control of the pest being to treat localized outbreaks promptly and thoroughly, thus preventing the spread of the pest over a wide area.

Since the completion of this article, the results of dusting experiments carried out by W. R. Carpenter & Co. Ltd. are to hand. Using lead arsenate diluted with kaolin containing a sticker, and checking results by counts of *Sexava* before and after dusting, they claim great success. The experiments were conducted at Agita Plantation in the western islands.

PLAN AND SPECIFICATIONS FOR A SMALL HOT AIR DRIER.

By F. O. Moody.

A native-operated half-ton hot air drier in the vicinity of Rabaul, which has been kept under observation for some considerable time, has yielded such consistently good results that we have caused plans and specifications of the building to be prepared by the Department of Public Works and these are published herewith for general information.

The plans and quantity estimate speak for themselves and the following additional notes are appended:—

Flue pipes.—The pipe from the fire-box into the heating unit and chimney is of 12-in. diameter cast-iron piping, while the heating unit consists of a number of 42-gallon oil or benzine drums fitted into each other and, if possible, riveted together.

Draught.—The pipes of the air-inlets are continued to just under the heating unit; the exit vents for moisture-laden air end just under the iron roof of the drier.

Trays are built of wooden frames reinforced at the corners by galvanized iron binding and cross-straps of the same material; a further strip can also be placed across the centre and bottom of each tray.

Fire-box and chimney-flue are entirely separated from the drying chamber to eliminate the risk of fire.

Method of drying.—The 40 trays carry each almost 56 lb. of green coco-nut meat, loosely laid in the trays in a single layer, so that, as far as possible, the pieces are not piled in on top of each other, thus ensuring perfect draught.

This drier should successfully deal with 1 ton of green meat, or approximately ½ ton of copra every 24 hours, allowing in that period for the time required to remove the dried batch of copra and refill the trays with the succeeding charge of green meat.

Temperature should be maintained at a constant 120° to 140° F. throughout the drying process.

MATERIALS FOR HOT AIR DRIER.

Item.	Description.	Size.	Quantity and Remarks.
	CONCRETE WORK.		
1	Cement	Casks 19 ..	
2	Stone	½″	5½ cubic yards
3	Stone	¾″	5½ cubic yards
4	Sand (clean, coarse)	.. .. ..	5½ cubic yards
5	Mild steel rods	½″ diameter ..	350 feet—235 lb.
6	Bricks, fire	.. .. ..	600
7	Rag bolts, nuts and washers ..	6″ x ¾″	40
8	Furnace grate and door	.. .. ..	1 only
9	Sheet steel	15″ x 15″	1 only

MATERIALS FOR HOT AIR DRIER—*continued.*

Item.	Description.	Size.	Quantity and Remarks.
	CARPENTER.		
	All Timber Hardwood (Wrot.).		
10	Bottom plates (Wall)	4″ x 2″	1/18′, 1/15′
11	Top plates	4″ x 3″	1/18′, 2/15′, 1/13′
12	Bottom plates (Kiln)	4″ x 3″	2/18′, 6/7′
13	Top plates (Kiln)	4″ x 3″	2/18′, 4/7′
14	Studs	4″ x 4″	12/5′
15	Studs	4″ x 2″	6/5′
16	Posts	4″ x 4″	3/7′, 4/8′
17	Rails	4″ x 2″	1/18′, 1/14′
18	Trimming studs	4″ x 2″	2/7′
19	Sill	5″ x 1½″	1/18′, 1/14′
20	Rafters	4″ x 2″	12/9′, 5/11′
21	Ridge	8″ x 1¼″	1/21′
22	Roof battens	3″ x 2″	8/21′, 4/13′
23	Fascia	9″ x 1¼″	2/21′, 1/13′
24	Barge	7″ x 1¼″	4/9′, 2/11
25	Ridge	4″ x 2″	1/18′
25A	Tray rests	3″ x 2″	1/18′
26	Gable studs	4″ x 2″	1/16′, 2/4′
27	Tray runners	2″ x 2″	80/7′
28	Door frames	3″ x ½″	5/10′, 5/14′
29	Tray frames	2″ x 1¼″	80/7′, 80/13′
30	Vent frames	5″ x 1″	53′
31	Vent doors	7″ x 5″ x 1″	14 pieces
	IRONWORK.		
32	Galvanized iron, corrugated	6/5′, 9/6′	22/8′, 8/10′ x 24 G.
33	Galvanized gutters	5″	10/6′ x 24 G.
34	Galvanized brackets	1″ x 16 G.	20
35	Galvanized ridge capping	18″	4/6′ x 24 G.
36	Downpipe (galvanized)	3″	4/6′ x 24 G.
37	Galvanized plain iron	30″ x 72″	16 sheets
38	Galvanized plain iron	24″ x 72″	10 sheets } 24 G.
..	Galvanized plain iron	36″ x 72″	5 sheets
38A	Galvanized hoop iron	1¼″	280″
	GENERAL.		
39	Copra wire	36″	242 feet
39A	Copra flue pipe	8″ diameter	11 feet
40	Copra flue pipe	10″–12″ diameter	10 feet
41	Oil drums	40-gal.	8
42	Cast iron pipe	12″ diameter	24″
43	Hinges, galvanized tee	12″	5 pairs
44	Hinges, galvanized tee	6″	7 pairs
45	Springhead, galvanized	2¼″	7-lb. packet
46	Screws	1¼″	1 packet
47	Clouts, galvanized	1¼″	3 lb.
47A	Rivets, galvanized, No. 10	..	1 packet
48	Nails, R.H.	4″	4 lb.
..	Nails, R.H.	3″	8 lb.
49	Solder	..	4 lb.
50	Spirits of salt	..	1/3 pints
51	Oil paint	..	1 gallon

One European and two trained natives should build job in three weeks.

A HANDY AND INEXPENSIVE " CEYLON TYPE " KILN DRIER.

By E. Caulfield-Kelly.

Building.

Fifty-two feet long by 22 feet wide, of native material, with kunai or sac-sac roof, having a covered vent in the ridge, after the fashion of a " jack-roof ". No flooring is necessary.

Fire-pit.

This may be dug as deep as 3 feet below ground level, or less, according to the nature of the ground and the height of the water-table, and should be 46 feet x 16 feet in dimensions, with a hard dry bottom of either cement or firebricks, or even tamped earth or coral. Its position in the building should be with one end against the back wall and one side along one of the side walls.

Drying-bed.

Forty-eight feet x 18 feet, made with timber and strong wire mesh—rabbit wiring is quite suitable—the frame to be strongly re-inforced to carry about 5 tons. This is supported immediately over the fire-pit on posts of mangrove or other native hardwood, so that the bottom of the tray is at least 7 feet above the floor of the fire-pit. The space from ground level above the pit to the level of the bed should be enclosed on three sides by galvanized iron nailed on to the inside of the supporting posts, so that the heat and gases ascend from the pit directly under the bed. The fourth side, which should be the end of the bed at the entrance end of the building, should be enclosed by sliding or hinged doors to provide an entrance to the pit to lay and tend the fires. The bed, being directly over the pit, will, of course, have one of its ends against the back wall of the building, and one of its sides along one of the side walls. This will allow an operating space of 4 feet at the entrance end of the building and 4 feet along the length of the drying-bed.

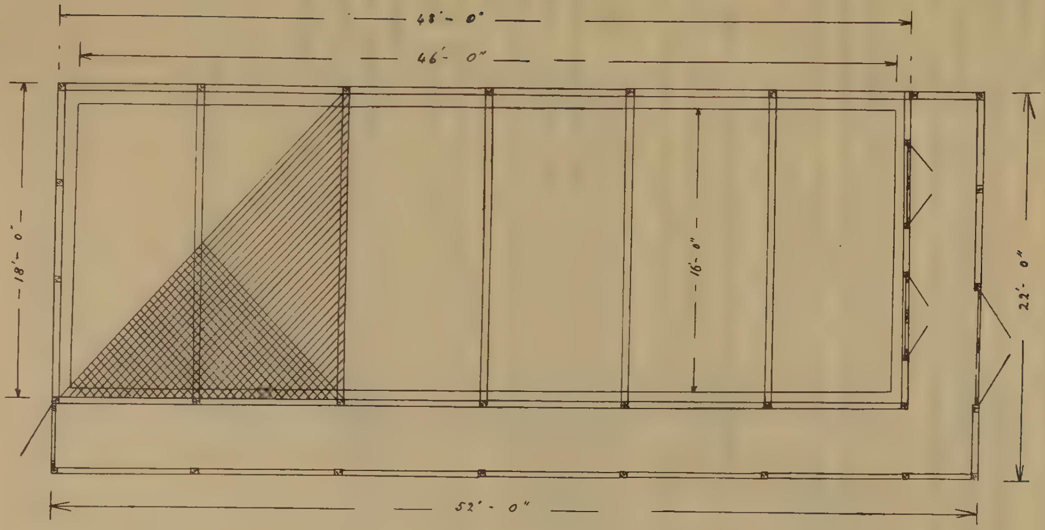
Firing.

Perfectly dry half-shells, quite free from husk, must always be used. Ten double lines of these, cupped into each other, should be laid down across the width of the fire-pit. These double lines should be 4 feet apart, and, leaving a space of 1 foot at each end, should therefore be 14 feet long. The double lines should be laid side by side and touching, but not over each other. Each line should be lit at the opposite end from the preceding line, i.e., each alternate double line is ignited at the same end. Ten of these double lines will be sufficient to fill the pit and will constitute one charge. Each line will burn for about four hours and fires must be kept well up for the first eighteen hours.

Process.

Seventeen thousand nuts are husked and placed convenient to the drier. Each nut is split in two and laid aside, concave side downwards, for an hour or so to thoroughly drain. If possible, the meat should then be sundried (concave side upwards) for the first day and drying then completed in the kiln for three further days. On the first day in the kiln, the half-nuts are either placed or " lined "

A HANDY CEYLON DRIER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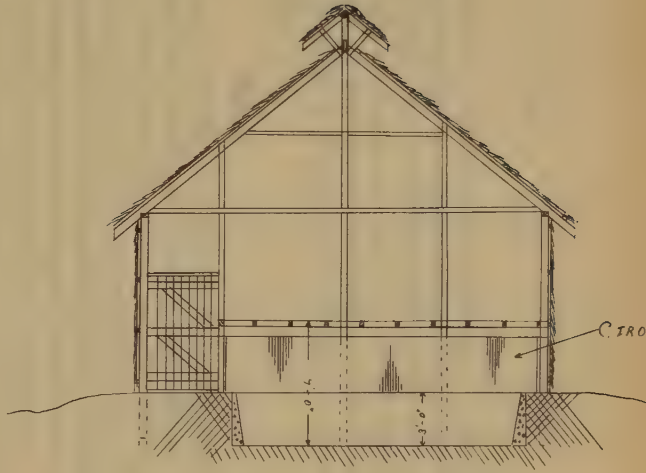

concave side upwards and stacked to a height of 10 inches to 1 foot in such a manner that the heat and gases from the pit may circulate freely through them. On the second and third days in the kiln the half-nuts need not be so carefully placed, but may be thrown haphazardly on the bed, the lower nuts each day alternating with the upper ones. If sun drying on the first day is not possible owing to weather or other conditions, a further twelve hours in the kiln may be necessary to ensure full drying.

Notes.

Kilns of this type have been operated successfully on the Madang coast on a group of properties which turn out 1,000 tons of copra per annum.

Husking nuts is a task at which native labourers become quickly proficient and an average task for a day-unit is to collect and husk 500 nuts.

The most useful husking apparatus is a sharp-pointed piece of 1-in. flat iron, fixed in a plank, on which the labourer can sit to steady it, but a piece of pointed mangrove or hardwood driven into the ground is also quite effective.

Six half-shells cupped into each other will cover a foot of fire-line so that the shells of 960 nuts will be sufficient for a charge of ten lines. No knives or shovels are required in the drier as the meat will drop out of the shells, or can easily be removed by hand when quite dry, and the copra, being in large pieces, can be handled without shovels.

Wastage in copra cutting and loss of small pieces will be entirely eliminated.

No firewood gangs are necessary with this process as the shell from each batch of copra cured will be more than sufficient to dry the succeeding batch and, incidentally, will be quite dry.

Constant attention to every detail will be necessary for a month or so until the labourers thoroughly understand their tasks. This applies especially to the firemen, but the process will be found eventually to be more economical than ordinary hot, air drying, whilst a really first-class copra can be turned out with reasonable care.

The half-nut pieces of copra can be again halved or even quartered if desired when bagging in order to reduce the number of bags per ton required.

The proportions of the drier can be reduced or increased in proportion to the output of a property.

The shell fires will provide a smoke-free heat and hot gases only, provided that no husk is left adhering to the shell and that it is quite dry and free from dirt.

To obtain the first batch of good clean shell it would probably be worth while to dry the first 17,000 nuts by ordinary smoke fires and treat the first batch of copra cured as smoke dried.

A further advantage of this would be that the interior of the building, especially the roofing material, would be protected to a certain extent by the smoke against subsequent insect attack.

Until the labourers are quite proficient it may be necessary to pick over the first few batches of cured copra for smoke tainted or discoloured pieces and submit these as smoke-dried copra.

BRUS TOBACCO FOR NATIVES.

George H. Murray.

Increased prices and irregularity of transport have added to the difficulties of the planter with regard to the issue of rations to native labourers. Part of that issue has been stick tobacco imported from the United States of America and as attempts to produce a similar article in the Territory, acceptable to natives, have proved a failure, " brus ", or air-cured tobacco, is recommended as issue instead of the manufactured article. This is accepted by the natives, even preferred by many bush natives who have not become accustomed to the manufactured article. Planters, if they choose, can produce " brus " on their plantations and thus reduce costs considerably and the following instructions have been written for their benefit. Although ordinary air or open barn-cured " brus " is sufficient for the purpose, the final section in the article deals with further fermentation of the leaf to improve the bouquet and reduce the " bite " which are not objectionable to natives, but, nevertheless, this would increase the value of the ultimate product for the planter who may eventually desire to produce tobacco for the open market.

Tobacco requires a well-drained soil but not too sandy and good cultivation is essential for success. The ground should be thoroughly broken up, reduced to a fine tilth and all weeds and grass removed as any check in the growth of the plant will have an adverse effect on the quantity and quality of the leaf.

In preparing seed beds every care must be taken to ensure good drainage and it is therefore necessary that they be raised fully 6 inches higher than ordinary ground level. There need be no limit to the length of the beds, but they should not be more than 4 feet wide for ease in weeding and watering. The ground should be sterilized before sowing the seed and the simplest way of doing this is to pile broken-up dry bushwood to a depth of 5 or 6 inches on top of the seed beds after all preparatory work has been completed. This should be burnt and when the fire has died down all partially burnt sticks, twigs and charcoal should be carefully removed and all the ashes incorporated with the soil by raking deeply backwards and forwards. The fire will destroy all ground insects, fungus spores and most noxious bacteria. I have found even large millipeds 6 inches from the surface all scorched up by this method, while potash and other elements in the ashes act as fertilizers to the soil. Even natives realize the advantage of this treatment as they frequently sow their tobacco seed where logs or stumps have been burnt.

After the ashes have been thoroughly incorporated with the soil the surface of the bed should be levelled off with a piece of straight-edged timber and by the time the bed is thoroughly cooled down, three or four days later, it will be ready for receiving the seed.

The seed is very minute and it is best to mix it with ashes as its distribution, if sown broadcast, can be more readily noticed. Personally, however, I prefer sowing even tobacco seed in rows about 3 inches apart in the shallowest of drills and pressed down with a smooth board as the seed is so minute that it must not be covered deeply. The beds must be kept continually moist but not wet and if allowed to dry out for a single day the sprouting seeds or seedlings will be killed. The seed bed must be kept shaded against the rays of the sun and this is easily done by having well plaited bombons the width of the bed. The bomboms should not be more than 6 or 9 inches above the seed bed until after the young plants appear when the shade should be gradually raised as the plants increase in size. If bombons are not easily obtainable, a good shade can be provided by laying lengths of kunai flat on frames with thin laths of bamboo or similar plant to keep the kunai leaves in place. This latter method is the one used in the tobacco Proefstation, North-East Sumatra, and it served the purpose quite well. Every care must be taken in the way the shading operation is handled for if kept heavily shaded too long the young plants will become leggy and weak. Some recommend the use of cheese cloth but this is quite unnecessary for ordinary tobacco, although highest quality of tobacco is raised even to maturity under such shade in Cuba.

When the seedlings have developed two pairs of leaves they should be pricked out and planted in a nursery bed 4 inches apart to make sturdy plants, so that they will not feel the shock of transplanting to the open field when 5 or 6 inches in height.

The distance of planting is somewhat variable according to the type of tobacco desired, but under New Guinea conditions rows of 3 feet apart and 18 inches in the row are satisfactory, as there is no mechanical cultivation in the Territory which would require wider spacing.

The plants should not be permitted to develop side-shoots, all of which should be nipped off as soon as seen. When the plants have developed twelve to eighteen leaves, they should be topped, but due care must be taken that this is not done too soon, otherwise it will encourage side-shoots—the leaves should be well developed before the plant is topped.

To obtain leaves of the best quality they should be harvested separately when fully ripe, which can be judged by the appearancee of the leaves, which will become dull in colour. For cheaper grades of tobacco the whole plant can be cut off close to the ground when the greater number of leaves are ripe.

The curing of tobacco requires special training and experience, and those contemplating the production of "brus" tobacco would be well advised to adopt a simpler method common amongst many small growers even in many parts of America to-day. If leaves are to be picked separately, the harvesting can be done when the plant is about four months old, commencing with the lower leaves, which are the first to ripen. Experience is required to know just when they are ripe enough for harvesting, as individual plants vary to a certain extent in ripening. Besides, judgment in the appearance of the leaf ripeness can be tested by bending the midrib, and the snap will give an idea whether the leaf is still too green or ripe.

Whether the leaves are picked singly or the whole plant is cut all the crop should go into a curing shed (a good kunai roof gives sufficient covering) to protect the crop from sun, dry-air currents and excessive humidity.

Hung on sticks suspended horizontally in racks, the leaves in pairs, if picked singly, or the whole stem, undergo a slow curing process, or dry fermentation, gradually turning yellowish brown and becoming tough. The length of curing depends on the kind of leaf and temperature, but from three to six weeks is sufficient to develop the nicotine content and correct leaf texture. In rainy weather fires made of dry coco-nut shell, free of coco-nut fibre, as used in a Ceylon copra drier, will prevent damage from excess moisture in the leaf. In North-East Sumatra, which produces the highest-priced tobacco in the world, the curing sheds are of great size, but are built entirely of atap, i.e., sak sak, or preferably nipa palm leaves, with ventilators in roof or on the sides that may be raised or lowered as required.

The elaborate curing sheds used for pipe tobacco are quite unnecessary for " brus ".

Due care must be taken that the crop is grown in the right season, otherwise the crop will prove a complete failure. Naturally, the leaves should ripen in the dry season, so that the seed should not be sown more than about two and a half to three months before the wet season is over.

Fermentation.

After being air-cured the tobacco leaves can be taken off the frames and made into small bundles, when they can then be stored for a few months if necessary. Complete fermentation can be commenced almost immediately after air-curing has ceased, and to do so a simple method is as follows:—

The bundles of leaves are spread on the floor in layers forming piles 10 or 12 feet long, about 5 feet wide and 6 to 7 feet high, which will contain roughly half a ton of leaf. If the leaves appear too dry it may be necessary to give them a slight sprinkle of water to start fermentation. A close watch must be kept on the temperature, which should not be allowed to go higher than about 125 deg. to 130 deg. It will be necessary to break down the heap and rebuild several times to get an even temperature, but fermentation should be complete in about six weeks. The leaves are then ready for baling prior to shipment to the manufacturers. However, as stated in the earlier part of this article, full fermentation is not necessary for " brus ". The above particulars are given for the planter who desires to reduce the " bite " and improve the bouquet, thus producing a finer article, and, when he has had sufficient practice, details can be given for producing a higher-quality tobacco.

THE VALUE AND USES OF METEOROLOGY.

By B. G. Challis.

This article is an explanation in simple terms of the practical uses and benefits to be derived from meteorology, which may be defined as that part of natural science dealing with the factors influencing weather and climate.

The study of weather and climate is important to people in many spheres of activity. At first sight it may appear that such people as agriculturists, aviators and mariners are the only ones vitally concerned with this subject, but merchants, engineers, contractors, medical officers, insurance men, caterers, leaders of defence forces and many others are among those who find a knowledge and the study of weather conditions essential in their respective callings. A few instances will be cited to illustrate the importance of meteorology and the correlations between meteorology and the various interests operating in this Territory.

At the chief town in each of the various administrative districts of the Territory there is a climatological station where barometric pressure, temperature, humidity, wind, visibility, cloud and other weather phenomena are recorded. In addition, there are some 60 stations which forward to this office in Rabaul, immediately after the close of each month, particulars of their rainfall records on a form, which also makes provision for notation of wind direction and force, cloud scale and any other available information, such as thunderstorms, dew, &c. When received by the central bureau at Rabaul these particulars are transferred to a permanent register and are then available on application.

For historical purposes it is interesting to note that climatic changes have occurred from one geological epoch to another. Geology teaches us that there have been great changes in the world's climatic conditions since its earliest formation (in pre-Cambrian period) through the various geological epochs—Palaeozoic, Mesozoic, Tertiary and Quaternary.

Remains of plant and animal life are amongst evidence of these climatic changes. The presence and disappearance of ice-fields and the transformation of forest and desert also support such changes.

Many theories are propounded regarding the causes of climatic changes, but so far a satisfactory solution is still awaiting authoritative acceptance. However, these changes become scarcely appreciable within our own life-cycle unless we can refer to records registered by instruments.

Through the courtesy and assistance of various observers stationed throughout the Territory it is possible, where the records cover a sufficiently lengthy period, to determine the climate of the different localities and its effect on agriculture and other kindred callings.

There is, of course, a difference between weather and climate. Weather is the meteorological condition for the 24 hours ensuing. Climate is the average weather condition over a number of years. The weather changes so frequently and is notoriously capricious in its behaviour during the course of a year, but its constancy or average over a period of years will enable a description to be made of the "climate" of a selected place, and at the same time act as a guide to what may be expected of the average behaviour of the weather. Accurately recorded weather conditions for a month or so are practically valueless, and the recordings must be continued over a lengthy period to have any marked value.

Meteorology is not an exact science. The movement of the various atmospheric factors follows no set plan, so that a vast field of research and future study lies ahead for students of meteorology, particularly in its application to this Territory.

As climatic factors vary in different localities it is obviously necessary to record them at as many places as possible, and wherever private rain gauges are installed the central bureau would greatly appreciate receipt of such further records as observers may care to submit.

It is a natural function and duty of this office to publish from time to time such information as it is able to collect by the co-operation of observers, and it should be noted that already considerable climatic data has been published in previous issues of this *Gazette*. It is hoped that the published information proves its usefulness and will lead to a more accurate knowledge of the various climates to be found in this Territory.

Agriculture.

Dr. Bryce, formerly Director of Agriculture in New Guinea, and now directing the agricultural welfare of Nigeria, stressed the importance of climate on agriculture in the following words:—

> The influence of climatic factors on the crop yield is of course recognized by everyone. Of equal and in some instances of greater importance is the influence of climatic factors on the incidence of fungus diseases and insect pests. It has been stated by Sir E. J. Russell that the loss to agricultural crops in Britain through the ravages of fungi and insects is probably at least 10 per cent. of the total value of the crops, or some £12,000,000 per annum. 'The saving fact seems to be that the pest does harm only when three sets of conditions happen to occur together: the pest must be present in the attacking state; the plant must be in a sufficiently receptive state; and the conditions must be favorable to the pest.' The chief conditions that favour the pest or otherwise are climatic, and a sound knowledge of the local climate is frequently of great aid in devising means of combating the pests and diseases. For example, 'in the Sudan some degree of control over the cotton thrips has been effected by giving the plant protection against the drying north wind and so maintaining a rather more humid atmosphere—a condition in which the plant flourishes more than the pest.' A knowledge of the climatic and essential seasonal conditions which favour the boll weevil of cotton in the United States has led to alterations in the cultivation of the crop in order to obtain a quick-growing and early-maturing variety in infested districts, a line of investigation which seems at present to offer the most hopeful means of controlling the pest.

A perusal of the article submitted by the economic botanist in this issue will reveal to the reader the stress laid on the particular weather conditions in relation to the diseases of coco-nuts. Similar importance is attached to the welfare of other crops in relation to rainfall and other climatic factors, for unless the planter is aware of the climate of a particular area it would merely be gambling with his fortunes if he ventured on a planting scheme in which the generally known weather conditions are likely to have an adverse effect on the particular crop chosen.

Some varieties of crops require a short growing season and others a long one. For instance, to cite the case of cotton, which may prove a particularly remunerative crop now war has broken out, it is possible to grow long stapled cotton successfully where the crop has a long growing season or where it can be irrigated when rain has ceased falling. So that a prospective planter of this crop would choose the variety of cotton best suited to the particular climate of his settlement.

When reliable information is available for a particular district for reference at a central bureau the intending settler may be supplied with advice on the suitability and prospects of any particular crop with a greater degree of accuracy and certainty. For instance, in the Gazelle Peninsula he would not sow a grain crop in October when he knows the length of time it takes to mature will require it to be harvested in the middle of the wet season. Any experienced planter will, therefore, make good use of his available climatic records and their variability.

The Governments of Germany, Holland and the United States of America in particular make a keen study of climate and use this knowledge to the best advantage, and we might well follow them in this respect.

An examination of the rainfall records of Rabaul and Manus indicates, at a glance, that the latter town receives nearly twice as much rainfall as Rabaul, and that Rabaul has a distinct dry season which is essential to the success of some crops, whereas it would be detrimental to attempt to cultivate a similar crop at Manus, which experiences no regular dry season.

To cite another instance, a case has just come to notice of a plantation on the mainland which was recently abandoned simply because of unsuitable soil and climatic conditions in that district. The coco-nuts on this plantation thrived at first but later succumbed. Had inquiries been made and advice sought regarding the average climatic conditions of this area over a period of years such a costly mistake could have been averted.

Generally speaking rain is essential for growth of leaf and wood and sunshine for profuse blossoming and good setting of seed. Many insects are badly affected by excessive rain, particularly bees and flies, which become fungus-ridden and perish under such conditions, while lack of rain or sunshine retards vegetative growth and causes the plants to wither and die.

Aviation Weather Service.

Aviation services regard as essential a knowledge of weather conditions along the route over which they operate, especially prevailing weather at landing places. In response to the writer's questions when discussing the value of weather advices with a flying-boat captain, he emphatically stated, "It is sweet music to our ears to hear the actual prevailing weather conditions." Weather, apparently, has a marked psychological effect on aviators, and it greatly relieves their minds to receive aeradio advice of the weather they are likely to encounter and especially that prevailing at their next landing place.

It is interesting to note that at all airports of call on the air mail route from Sydney to Rabaul trained officers are stationed to make available weather messages for the information of aircraft. Prior to departure from each aerodrome *en route* the pilot signs a form on which is indicated weather conditions between points of departure and ports of call.

As a guide to the most favorable altitude at which to fly weather observers inform the pilots of the strength and direction of winds in the higher atmosphere. These are ascertained by the aid of pilot balloon observations, which are carried out by tracing through a theodolite and noting at fixed intervals of time the track and movements of suitably coloured rubber balloons filled with hydrogen. These balloons are so light in comparison with their size that they immediately adjust themselves to the speed and direction of wind flow in the various layers of the atmosphere. By taking advantage of favorable winds not only is there a saving in time gained by an increase in speed but also a great saving in petrol consumption.

On all aerodromes it is of paramount importance that a pilot should know the exact direction and approximate velocity of the wind at ground level, particularly when landing, and a wind direction indicator is always installed for this purpose. This may take the form of the usual wind sock which blows out from a pole in the direction of the wind, or in more modernly equipped airports, a wind vane is attached to a large white arrow which is easily visible from the air to mark the wind direction. Smoke fires are also of assistance at actual ground level itself, especially on aerodromes which have only a one-way runaway.

Aeroplanes usually land into the wind, but on narrow runaways it sometimes becomes necessary to land partly or completely across wind. In these cases drift has to be counteracted by depressing the wing tip of the machine into the direction from which the wind is blowing, thereby offsetting the possible drift by a corresponding amount of side-slip into the wind, hence the necessity for knowledge of direction and velocity.

Although not within the scope of services provided by this Territory, it may be mentioned that at many air force depots a special 'plane, which co-operates with weather bureaux, is sent up daily to a height of 25,000 feet to ascertain atmospheric conditions at various altitudes.

In passing it may be noted that, since we have so many aerodromes and landing places at high altitudes in this Territory, with decreased barometric pressure associated with increasing height and a more rarified atmosphere, an increased runaway is required for taking off and landing. The length of the run for take-off is increased by 15 per cent. at 2,000 feet, 25 per cent. at 3,000 feet and 50 per cent. at 5,000 feet.

The information given by weather observers for the benefit of aircraft comprises—

(*a*) Barometric readings (essential for night flying or when flying " blind " through cloud or fog).
(*b*) Humidity.
(*c*) Direction and force of surface wind.
(*d*) General remarks upon present weather.
(*e*) Total amount of cloud in tenths of sky cover.
(*f*) Type and amount of low clouds with direction of movement.
(*g*) Type and amount of middle clouds with direction of movement.
(*h*) Estimated height of the base or underside of low clouds.
(*i*) Horizontal visibility.
(*j*) Upper winds.

This information can be condensed, coded and transmitted by radio to aircraft in flight.

The most feared factors as far as aviation is concerned are thunderstorms and fog. Low clouds over a landing place often present difficulties to aviators, and in this respect observers can proffer welcome advice by giving information as to the location of any clear spaces where the 'plane might come through.

Vast amounts are spent annually on aviation meteorology, and from press reports within the past few months we learn that Pan American Airways, in conjunction with their Trans-Pacific Air Service, provided for over 100,000 francs expenditure on their aviation meteorological service at Noumea in our neighbouring territory.

In the United States of America, the Department of Agriculture, which controls the weather services of that country, has submitted $990,000 as their requirements to be expended on research, while its actual cash appropriation to maintain the existing aviation weather service for the fiscal year ending 30th June, 1940, is $3,700,000.

In connexion with the Trans-Atlantic Air Service it may be mentioned that the French steamer *Carime* (6,400 tons) was engaged cruising in the Atlantic Ocean during 1937-38 specifically as a meteorological and radio station collecting valuable information on the atmospheric conditions of the Atlantic, and just prior to the outbreak of hostilities a co-operative plan was arranged for exchange of weather data collected by various ships crossing the Atlantic for the benefit of shipping and aviation.

Health.

A knowledge of climatology in relation to different localities is essential to the medical profession not only from a general public health point of view, but to aid its officers to diagnose causes of ill-health and which places to recommend to their patients requiring either a bracing or sedative sanitorium.

In selecting healthy or unhealthy localities the general concern of the medical officers regarding a place is to obtain information as to the exposure, elevation and drainage.

Exposure refers to what degree a particular locality is open to or sheltered from the sun or winds and the influence of modifying forces such as sea or mountains and the effects of these forces on a locality. The penetration of the sun's direct rays assists the bactericidal powers, whereas low-lying, inland valleys will be liable to mists and perhaps produce detrimental effects on the patients.

Elevated altitudes are usually associated with purer air and feelings of personal buoyancy as a result of the rarer atmosphere and its lesser moisture content than stations on the littoral or sheltered valleys where there is usually a greater range of temperatures.

Porous soils are a factor tending towards a healthy locality, whereas impermeable soils are generally unhealthy and in such cases an engineer may be called in to suggest a suitable drainage scheme to overcome the difficulty.

Meteorology teaches us that the atmosphere is like a blanket preventing the penetration of ultra violet rays so that the higher the elevation and more rarified the air the greater the healing power of such rays. Although Zulus know nothing of the principle of ultra violet rays, they have learned from experience their healing virtues, and it is customary for them to go to the tops of their highest mountains to expose wounds to the sun with beneficial results. At lower levels the ultra violet rays have a beneficial effect from dawn to about 8 a.m., but after that the effect is negligible.

It is therefore necessary for the Health Department to have a knowledge of the various climatic factors including sunshine, rainfall, humidity and temperatures to enable them to deal satisfactorily with matters coming under their jurisdiction.

Engineering.

Meteorology has also many applications to engineering. It may be noted that in connexion with air-conditioning purposes to arrive at an ideal indoor temperature the builder would ascertain the average outdoor temperature and in the case of many coastal New Guinea stations he would probably strive for about 71°F. as an ideal indoor temperature.

Recently an electrical engineer conferred with the department's bureau to ascertain the minimum shade and maximum solar temperatures experienced in Rabaul. This information was necessary to enable him to make allowances in the stress on electric light wires which his company propose to lay in a single span of half a mile from the vulcanological observatory site to a base at the foot of the hills encircling Rabaul.

Ballistics.

At present most people in this Territory are military minded, and from our knowledge of the theory of gunnery and small arms we know that weather conditions have a decisive bearing on the motion of the projectiles during flight from muzzle to target.

Before leaving the factory, .303 service weapons are tested for certain standard conditions which include—

(*a*) Still air—at all points of the projectiles' trajectory.
(*b*) Ground pressure of 30.00 inches of mercury at 32° F. in latitude 45 degrees.
(*c*) Ground temperature of 60° F.

Allowance must therefore be made for any departure from these standard conditions. The longer the range being used the more necessary it will be for adjustments to suit the particular prevailing weather.

For naval gunnery and artillery such other climatic factors as relative humidity and lapse rates must receive consideration.

The effect of wind on the trajectory of a bullet or shell, especially that of a cross-wind, is a factor for which due allowance must be made.

For accuracy of shooting with anti-aircraft and long-range guns, it is necessary to know the equivalent constant wind, which may be defined as the average velocity and direction of wind from the firing point to the top of the trajectory.

The velocity and direction of surface and upper winds are ascertained daily at Rabaul and Salamaua by means of pilot balloon observations. If the presence of cloud prevents a speedy pilot balloon observation, the weather observer may ascertain the strength and direction of ballistic winds by firing a shell to burst at a known height into a patch of clear sky and tracing its smoke drift through the weather observer's theodolite.

Where instruments such as anemometers, wind vanes or pilot balloons are not available to measure the direction and force of surface winds, a due appreciation on the wind's direction and force may be gained by a study of its effect on trees, grass, smoke and other objects rather than on physical sensations. The annexed universally adopted Beaufort Scale Wind Force Table will enable the observer to discriminate between the various types of wind.

So far as our records show in New Guinea, there is nothing to indicate that winds greater than force seven on the Beaufort Scale have been experienced near ground level, although a wind of 60 miles per hour was registered near the 18,000 feet level a day after the departure of the tourist ship *Strathnaver* from Rabaul—28th August, 1939—when it may be remembered that during this vessel's stay we experienced perhaps our most severe squall for many years. However, this squall was of very short duration.

As altitude increases there is a noticeable rarity in the air which corresponds to a decreased atmospheric or barometric pressure. As the barometer falls, less air resistance is thus offered to a projectile so that at hill stations such as Wau, Edie Creek or Upper Ramu, a rifleman must take into account the rarity of the atmosphere and deduct from his range $1\frac{1}{2}$ yards for every 100 yards. It should be noted that the barometer falls about 1 inch for every 1,000 feet altitude.

Every degree the temperature registers above or under 60° F. the rule is to deduct or add $^1/_{10}$ yard for every 100 yards of range. The following may be quoted as an example. At Edie Creek the range finder reports the distance to the target at 1,600 yards. Barometer records 23.00 inch and thermometer 80° F.

		Deduction.
Barometer	$7 \times 1\frac{1}{2} \times 16 =$	168
Temperature	$20 \times {}^1/_{10} \times 16 =$	32
Total deduction		200

Corrected elevation sight will therefore be 1,400 yards. Corrections may appear negligible for actual skirmishing conditions likely to be encountered in this Territory with small arm weapons, but it is obvious that for naval gunnery and artillery purposes, when the shell passes through a greater stress of weather factors, a knowledge of barometric pressure, ballistic temperatures and strength and direction of equivalent constant winds will be essential to accuracy of shooting, and in this respect the services of a weather officer or meteorologist can be of great assistance to a gunnery unit.

Summary.

In conclusion it may be stated that meteorology is so closely associated with health, habits, pleasure and various vocations in life that it warrants universal attention.

Meteorology covers such a wide field, and the factors which govern it are so variable in character that a net-work of weather observers is necessary to act as a guide for any intelligent discussion on climate and the probable behaviour of weather.

Illustrations have been given in this article to show the importance and value attached to this branch of science; also the necessity for observers in the various parts of the Territory continuing to submit weather data to a central bureau at the Department of Agriculture in Rabaul.

To quote John Ruskin on meteorology—

One following this science will find himself part of one mighty mind—a ray of light entering into one vast eye—a member of a multitudinous power, contributing to the knowledge and aiding the efforts which will be capable of solving the most deeply hidden problems of nature, penetrating into the most occult causes, and reducing to principle and order the vast multitude of beautiful and wonderful phenomena by which the wisdom and benevolence of the Supreme Deity regulates the course of the times and the seasons, robes the globe with verdure and fruitfulness and adapts it to minister to the wants and contribute to the felicity of the innumerable tribes of animated existence.

TABLE OF THE BEAUFORT SCALE OF WIND FORCE.

Beaufort Number.	Descriptive Title.	Abbreviated Descriptions.*	Specification for use on land.	Average speeds in the open.		
				Miles per hour.	Metres per second.	Feet per second.
0	Calm ..	Calm ..	Smoke rise vertically ..	Less than 1	Less than 0.3	Less than 2
1	Light air ..	Light wind	Direction shown by smoke but not by wind vanes	1–3	0.3–1.5	2–5
2	Light breeze ..		Wind felt on face; leaves rustle; ordinary vane moved by wind	4–7	1.6–3.3	6–11
3	Gentle breeze ..		Leaves and small twigs in constant motion; wind extends light flag	8–12	3.4–5.4	12–18
4	Moderate breeze	Moderate wind	Raises dust and loose paper; small branches are moved	13–18	5.5–7.9	19–27
5	Fresh breeze ..	Fresh wind	Small trees in leaf begin to sway; crested wavelets form on inland waters	19–24	8.0–10.7	28–36
6	Strong breeze ..	Strong wind	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	25–31	10.8–13.8	37–46
7	Moderate gale		Whole trees in motion; inconvenience felt when walking against the wind	32–38	13.9–17.1	47–56
8	Fresh gale ..	Gale ..	Breaks twigs off trees; generally impedes progress	39–46	17.2–20.7	57–68
9	Strong gale ..		Slight structural damage occurs (chimney pots and slates removed)	47–54	20.8-24.4	69–80
10	Whole gale ..		Seldom experienced inland; trees uprooted; considerable structural damage occurs	55–63	24.5–28.4	81.93
11	Storm ..		Very rarely experienced; accompanied by widespread damage	64–75	28.5–33.5	94–110
12	Hurricane ..	Hurricane	.. ..	Above 75	33.6 or above	Above 110

* The abbreviated list of descriptive terms is often used in plain language reports and forecasts.

EASTERN STANDARD TIME* OF SUNRISE AND SUNSET FOR THE YEAR 1940—RABAUL.

(Lat. 4° 12′ S. Long. 152° 11′ E.).

1. These times are for the upper limb of the sun and may be taken as correct to within one minute for Rabaul.

2. Subtract four minutes per degree of longitude for any place east of Rabaul. Add four minutes per degree of longitude for any place west of Rabaul. (Accuracy still being approximately within one minute of time.)

3. An additional correction must be made for latitude, for which the following table may be used:—

—	For Every Degree of Latitude—	
	South of Rabaul.	North of Rabaul.
	minutes	minutes
January	Subtract 1.5	Add 1.5
February	Subtract 0.9	Add 0.9
March	Subtract 0.1	Add 0.1
April	Add 0.7	Subtract 0.7
May	Add 1.4	Subtract 1.4
June	Add 1.7	Subtract 1.7
July	Add 1.6	Subtract 1.6
August	Add 1.0	Subtract 1.0
September	Add 0.2	Subtract 0.2
October	Subtract 0.6	Add 0.6
November	Subtract 1.3	Add 1.3
December	Subtract 1.7	Add 1.7

After this correction time should be correct to within approximately 2 minutes.

—	Rise.	Set.	—	Rise.	Set.	—	Rise.	Set.
	h. m.	h. m.		h. m.	h. m.		h. m.	h. m.
January—			February—			March—		
1 ..	5 44	6 05	8 ..	5 58	6 12	7 ..	..	6 07
2 ..	..	6 06	10 ..	..	6 13	8 ..	..	6 06
3 ..	5 44	..	13 ..	..	6 12	9 ..	..	6 05
4 ..	5 46	6 06	15 ..	..	6 13	10 ..	..	6 04
5 ..	..	6 07	17 ..	..	6 12	12 ..	5 56	..
9 ..	5 48	6 08	19 ..	..	6 11	15 ..	5 57	..
12 ..	5 50	6 09	20 ..	5 59	6 12	16 ..	5 56	..
16 ..	5 51	6 11	21 ..	..	6 11	17 ..	..	6 03
18 ..	5 52	..	22 ..	5 58	..	19 ..	..	6 02
20 ..	5 53	6 12	24 ..	..	6 10	21 ..	5 55	..
24 ..	5 54	6 13	26 ..	5 59	..	22 ..	..	6 01
28 ..	5 55	..	29 ..	5 58	6 9	23 ..	5 54	..
30 ..	..	6 12				25 ..	..	6 00
31 ..	5 56	..	March—			26 ..	..	5 59
February—			1 ..	5 58	6 08	27 ..	..	5 58
1 ..	5 56	6 13	3 ..	5 57	..	28 ..	5 53	..
5 ..	5 57	6 14	4 ..	5 58	..	30 ..	5 54	..
6 ..	..	6 13	6 ..	5 57	..	31 ..	5 54	5 58

* Data supplied by C. L. Anthony, Survey Office, Rabaul.

—	Rise.	Set.
	h. m.	h. m.
April—		
1	5 53	5 57
3	5 52	5 55
6	..	5 54
8	5 51	..
11	..	5 53
14	..	5 52
16	..	5 51
18	5 50	..
21	5 49	5 49
23	..	5 48
24	5 50	..
26	5 49	..
30	5 49	5 48
May—		
1	5 48	5 47
4	5 49	..
5	..	5 46
7	5 50	..
8	5 49	5 45
9	..	5 46
13	5 50	..
14	5 49	5 45
17	5 50	..
20	5 49	..
21	5 50	..
24	..	5 46
25	..	5 45
27	..	5 46
28	5 51	..
30	..	5 45
31	5 51	5 46
June—		
1	5 52	5 46
6	5 53	..
7	..	5 47
8	5 53	5 46
9	..	5 47
10	5 54	..
11	..	5 48
12	..	5 47
14	5 55	5 48
16	5 54	..
17	5 55	5 49
18	..	5 48
19	..	5 49
21	5 56	..
23	..	5 50
24	5 57	..
25	5 56	..
27	..	5 51
28	..	5 50
29	..	5 51
30	5 58	5 51
July—		
1	5 58	5 51
2	5 59	..
3	5 58	5 50
4	..	5 52
5	5 59	..
6	5 59	..
7	5 59	5 53
9	6 00	5 54
10	5 59	5 52
11	..	5 54
12	6 00	..
13	5 58	..
14	6 00	..
16	..	5 55
17	5 59	5 54
19	6 00	5 55
21	..	5 56
22	5 59	5 54
23	6 00	..
24	..	5 55
25	..	5 56
26	5 59	..
27	6 00	..
30	5 59	..
31	5 59	5 56
August—		
1	6 00	5 56
3	5 58	5 55
7	..	5 56
8	5 57	5 55
10	5 58	5 56
12	5 57	..
13	5 56	5 55
18	5 55	..
22	5 54	..
24	5 53	5 54
25	5 52	5 53
30	5 51	5 52
31	5 51	5 52
September—		
1	5 51	5 52
2	5 50	5 52
4	5 49	..
6	5 48	5 51
7	5 47	..
9	5 46	..
10	..	5 50
12	5 45	..
14	..	5 49
15	5 44	..
17	5 43	5 48
18	5 42	..
19	5 41	..
21	..	5 47
22	5 40	..
24	..	5 46
25	5 39	5 47
27	..	5 46
29	5 38	..
30	5 37	..
October—		
1	5 37	5 45
2	5 37	5 45
3	5 35	5 44
6	5 34	..
7	5 35	5 45
8	..	5 44
9	5 34	..
11	5 33	..
12	5 32	5 43
15	5 31	..
17	5 30	..
18	..	5 42
19	5 29	..
24	..	5 43
27	5 28	..
28	..	5 42
30	5 27	..
31	5 27	5 42
November—		
1	5 27	5 42
2	5 27	5 42
3	5 28	5 44
4	5 27	5 43
7	5 26	..
10	5 27	5 44
16	5 28	5 45
17	..	5 46
19	5 27	..
21	5 28	5 47
24	..	5 48
26	5 29	5 49
28	..	5 50
29	5 30	..
30	5 30	5 50
December—		
1	5 31	5 51
2	5 31	5 51
5	5 32	5 53
9	5 33	5 54
10	..	5 55
11	5 34	..
13	5 35	..
14	..	5 57
16	5 36	..
17	5 37	5 58
19	..	5 59
20	5 38	..
21	5 39	6 00
23	..	6 01
25	5 41	6 02
28	5 42	6 04
30	5 43	..
31	5 43	6 04

THE CHIEF CHARACTERISTICS AND USES OF SIX NEW GUINEA TIMBERS.

J. L. d'Espeissis, B.Sc., B.Sc.For., Dip.For.

Several New Guinea timbers have achieved a certain prominence during the last two or three years. The most outstanding of these is Laup, or New Guinea Walnut (*Dracontomelum mangiferum*). This walnut is the mainstay of the timber industry at present and it comprises the bulk of the timber exported. It is now creating a considerable amount of interest for veneer purposes in the United Kingdom, the United States of America and also in Australia. In fact exporters find it hard to cope with orders. The main difficulty with regard to the marketing of this species is one of supply. This is due to several reasons, namely, the scattered occurrence of the species, which calls for selective logging which, in order to be economic, requires greater mobility on the part of the logging organizations than the present conditions would appear to permit, a lack of sufficient shipping space, which temporarily prohibits an increase in output, while lastly, susceptibility to damage by internal borers, which necessitates the rejection of many logs for export purposes. However, in view of the increasing demand for walnut, it may be confidently expected that these difficulties will be overcome in time.

Erima (*Octomeles sumatrana*), which is suitable for veneers, plywood and general purposes is, after walnut, probably the best known New Guinea timber. It is being exported in small but steady quantities. Another fine cabinet type of timber, which is just beginning to receive attention, especially for veneers, is Irotu, or Bush Calophyllum (*Calophyllum* sp.). These three timbers, particularly walnut and erima, may be said to have been exported more than any other species.

Two timbers well known here, Kwila (*Afzelia* (*Intsia*) *bijuga*) and Kamarere (*Eucalyptus deglupta*) are the most favoured local hardwoods for constructional purposes throughout the Territory. These timbers, due to sea freights, cannot stand competition with equally good, if not superior, hardwoods overseas. Consequently, it would seem that the future for these timbers would lie in the supply of the local demand and, even for this purpose, it is probable that conservation of existing supplies will be necessary.

A widely spread and well-known timber deserving greater attention is Toan (*Pometia pinnata*). Due to the more frequent occurrence of this species as compared with others, throughout the coastal forests of the Territory, this timber must some day be of considerable commercial importance. Already limited quantities have been used locally and exported to Australia. It is not to Australia, however, with its plentiful supply of some of the world's best hardwoods, that one must look for the establishment of Toan as an export timber, but rather to New Zealand, South Africa and the East. Toan is somewhat similar in its main characteristics to Philippine Mahogany, or red Lauan, and consequently in time, with careful treatment, it must build up for itself a reputation as a fair general utility type of medium hardwood.

The following notes on the characteristics of these timbers will serve to give some idea of their real and potential uses:—

Laup or New Guinea Walnut (*Dracontomelum mangiferum*, Blume).

Colour	Sapwood white; truewood grey-brown.
Grain	Generally interlocked.
Figure	Attractive black stripe on the quarter, and also ribbon, due to interlocked grain; on the back face often without particular distinction.
Texture	Fairly coarse; slightly more open than Queensland walnut.
Weight	Approximately 47 lb. per cubic foot at 12 per cent. moisture content. Logs sometimes sink.
Seasoning	Seasons rapidly without degrade.
Workability	Light and easy to work under hand or machine tools. Nails easily; glues readily; suitable for both peeled and sliced veneers.
Finishes	Fairly coarse texture, requires filling, gives an attractive finish in natural colour.
Sizes	Available in full range of boards and joinery sizes and as veneers and plywoods.
Uses	A valuable walnut type for all high-grade cabinet manufacture. Particlarly suitable for sliced veneers.

Erima (*Octomeles sumatrana*, Miq.).

Colour	Sapwood light yellow; truewood light brown to greyish yellow.
Grain	Generally interlocked.
Figure	Striped figure due to interlocked grain on the backsawn face; ribbon figure on quarter-sawn face due to the same reason, also fine flakey figure. Similar to white Lauan or white Pacific Maple.
Texture	Fairly coarse.
Weight	Approximately 23 lb. per cubic foot at 12 per cent. moisture content.
Strength	A fairly soft timber. Modulus of rupture about two-thirds that of Douglas Fir and about half as stiff. Compressive strength a little lower than Douglas Fir. Low in impact strength.
Seasoning	Seasons rapidly without degrade.
Borer susceptibility	Pore size and starch content of sapwood suggest probable susceptibility to Lyctus attack.
Workability	Light and easy to work under hand or machine tools. Nails easily; glues readily; suitable for rotary peeling.
Finishes	Treatments suitable for Pacific Maple should be applicable.
Sizes	Relatively large size of logs yields full range of boards and joinery sizes, particularly wide boards. Is available as veneers and plywood.
Uses	Should be suited to all purposes now served by white Pacific Maple, It should find use for carpentry, coffin boards, corestock, furniture, mouldings, plywood, veneers, shelving and box manufacture.

Irotu (*Calophyllum* sp.).

Colour	Pink.
Grain	Fairly straight.
Figure	Attractive figure on the backsawn face, or rotary peeled veneer, due to fibres interlocked in bands tangentially—similar to *Calophyllum costatum* of Queensland, which is known under the name of Red Touriga. On the quarter it is without distinction.
Texture	Fairly coarse.
Weight	Approximately 40 lb. per cubic foot at 12 per cent. moisture content.
Seasoning	Seasons readily.
Workability	Relatively easy to saw and dress; nails and glues readily. Suitable particularly for peeled veneers.
Finishes	Attractive finish in natural colour.
Sizes	Should be available in full range of boards and joinery sizes, and as veneers and plywood.
Uses	Appears to have possibilities for interior finish, such as moulding, skirting, architraves, and for joinery, such as doors and stairways. In the furniture trade it should be suitable for cabinets, tables and chairs. It makes particularly attractive plywood when peeled and logs of this species are symmetrical and of suitable form for this purpose.

KWILA (*Afzelia bijuga*, A. Gray).

Colour	Yellow-brown when fresh, turning dark brown with age; sapwood light buff to pale yellow.
Grain	Slightly cross-grained.
Figure	Without distinction.
Texture	Moderately coarse; pores large, some contain conspicuous sulphur-yellow deposits.
Weight	Approximately 58.7 lb. per cubic foot at 12 per cent. moisture content. Logs sink.
Strength	A hardwood with static bending strength greater than Teak and Douglas Fir. Modulus of elasticity greater than that of oak; compression strength also greater.
Seasoning	Seasons readily with little degrade.
Workability	Easy to work, saws well, mortises cleanly.
Finishes	Takes glossy finish under tools, and high finish when polished.
Sizes	Available to order, locally, in full range of boards and constructional sizes.
Uses	Very resistant to insect and fungal attack, therefore durable when exposed to weather and in the ground; not, however, very resistant to teredo attack, therefore unsuited for marine work unless protected; corrodes steel. Particularly suitable for high-grade heavy constructional work, also for furniture and cabinet making.

KAMARERE (*Eucalyptus deglupta*, Blume).

Colour	Red brown.
Grain	Generally straight.
Figure	Characteristic stripe or ribbon on quarter-sawn face due to interlocked grain; back-sawn face without character.
Texture	Fairly coarse.
Weight	Approximately 52 lb. per cubic foot at 12 per cent. moisture content.
Strength	A moderately hard wood, with static bending strength slightly greater than Toan, as also are its modulus of elasticity and its compressive and impact strengths.
Seasoning	Readily seasoned.
Workability	A firm timber relatively easy to saw, but difficult to dress on the quarter-sawn face without tearing the interlocked grain. Mortises cleanly and produces sharp edges in moulding or shaping. Nails easily.
Finishes	Gives attractive finish in natural colour resembling a red Pacific Maple when quarter cut.
Sizes	Available in full range of boards and joinery sizes.
Uses	It should prove to be a substitute for red Pacific Maple for many purposes. Appears to have possibilities for all forms of interior finish such as flooring, lining, moulding, skirting, architraves; for joinery such as doors, stairways, and also for house frames. In the Territory of New Guinea it is the most-used local hardwood for general building purposes. In the furniture trade, also, it should be found useful. It is too hard, however, for satisfactory veneering.

TOAN (*Pometia pinnata*, Forst.).

Colour	Pink to light red brown.
Grain	Usually straight, but may be interlocked.
Figure	Usually without character, but sometimes has attractive broken stripe due to interlocked grain; pores prominent.
Texture	Fairly coarse.
Weight	Approximately 41 lb. per cubic foot at 12 per cent. moisture content.
Strength	A moderately hard wood with static bending strength slightly less than Douglas Fir. Modulus of elasticity about equivalent to that of oak. Compression strength about equal to oak. Impact strength low.
Seasoning	Readily seasoned.
Workability	A firm timber relatively easy to saw, but sometimes difficult to dress without tearing the interlocked grain. Mortises cleanly and produces sharp edges in moulding or shaping. Bends particularly well. Nails easily. Glues readily.
Finishes	Gives attractive finish in natural colour, somewhat resembling Queensland Maple. Amenable to the same range of finishing treatments as Queensland Maple.

Sizes	Should be available in full range of boards and joinery sizes and as veneers and plywoods.
Uses	Should prove a substitute for Lauan (red Pacific Maple, or Philippine Mahogany). Appears to have possibilities for all forms of interior finish such as floorings, lining, moulding, skirting, architraves; for joinery such as doors and stairways, and for house frames. In the furniture trade it should find use in cabinets, tables, chairs, household furniture, and especially in bent work. It makes attractive plywood.

New Guinea coastal forests, like most tropical rain forests, are characterized by the great number of tree species represented. The six species dealt with above are by no means the only species with commercial possibilities. Several other species have proved themselves to be most satisfactory for local use; while in addition to these, without considering the highland species, numerous other timbers of potential value occur in the more accessible coastal areas. However, the timber export industry is a comparatively new one, and due to the difficulty of placing new untried timbers on a fastidious market in competition with well known established species, the six timbers described here are the only ones to have obtained any prominence as yet. There is the possibility now, however, since war-time conditions have seriously restricted the importation of softwoods from America and Baltic countries, that the demand for this type of timber in Australia will give this Territory an opportunity to develop its light-coloured, light-weight timbers of the coastal forests as softwood substitutes. So far they have received little attention; and due to difficulties, such as blue staining caused by fungal attack, the small quantities exported in the past have not been favorably received. These difficulties, however, can be overcome; and it is hoped, with the demand which has arisen, and which is increasing, that these types will come into their own, and that the New Guinea timber trade will become firmly established; for it is only by more thorough utilization, that the present expensive selective logging can be avoided and the industry established on a really economic basis. Incidentally, such a development would give the newly inaugurated forest department greater opportunity to establish sound forestry practice in this country.

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AVOCADO CULTURE.*

(FARMERS' CIRCULAR 1.)

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In its native home, tropical and semi-tropical North and South America, the avocado (*Persea americana* Mil. and P. *drymifolia* Ch. and Sc.) is an important food of the inhabitants. In the Philippines, however, it is still considered a luxury fruit since the present price is not within the reach of many. Of the many species and varieties of fruit trees introduced into the Philippines, none has gained so wide a reputation within a short time as the avocado. Although it is said to have been brought into the Philippines from Mexico in 1890, yet it was not successfully grown here until 1903 from planting materials received from Hawaii, Costa Rica, and the United States of America. The Bureau of Agriculture (now the Bureau of Plant Industry) began the distribution of avocado in the Philippines in 1913, and with the co-operation of the College of Agriculture of the University of the Philippines, it is able to produce many avocado trees bearing fruits in many provinces. Approximately, 22,000 trees are now found growing in the Philippines, 4,500 of which are already bearing fruits.

Varieties.

Avocado trees vary in habit of growth; some are tall with short lateral branches while others have spreading branches. The leaves are usually medium thick and leathery, and they vary in shape and size. The flowers are borne in compact panicles generally at the end of the twigs. The fruits are variable in shape, size and colour. The surface colour of the fruit, when ripe, varies from light green to dark green, purple, brown, red, crimson, or maroon. The rind may be thin and delicate to thick and leathery and enclosing a large seed. The pulp is very nutritious, rich in fat, appetizing, with nutty flavour, and of a buttery consistency. There are three avocado races, namely, the West Indian, the Guatemalan and the Mexican types. Each of these types requires a different elevation for its development and possesses different characteristics, as follows:—

West Indian.—The fruit of this type has a poor shipping quality, loose-fitting, and with rather large seed. According to Stahl they contain from 4 to 7 per cent. fat. The skin is medium thick and is always smooth and leathery. The seed coats are usually separated, and the cotyledons are rough on the surface. The fruit stems are short. The Philippines grow varieties under this type as the Pollock, Family, Cardinal, Wilson, Waldin, Wester, and Baldwin.

Guatemalan.—This type has a thick woody rind, producing dull, large and rough fruits. The seed is small and invariably tight-fitting; the fruits are of good shipping quality, the meat of which is drier than that of the West Indian. The surface of the cotyledons is smooth. It contains more fat (from 10 to 13 per cent.) but less carbohydrates. The fruit usually is borne on long fruit stem. The young leaves are frequently reddish or bronze in colour instead of green. The Dickinson, Lyon, Tertoh, Taft and Tumin are the varieties of this type already cultivated in the Philippines.

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Mexican (*Persea drymifolia*).—The foliage is anise-scented, small, and sharp at the apex. The fruit is small with thin, smooth rind which generally adheres to the pulp and is of purplish black in colour. It contains a higher percentage of fat (from 12 to 15 per cent.). The seed is large with thin coats which are either separated or adhering to the cotyledons. The surface of the cotyledons is smooth. The varieties under this type that are already grown in the Philippines are Ganter and Puebla. Seeds of the Gottfried and Northrop were successfully introduced in 1924.

In planting avocado, one of the most perplexing problems is the choice of the right varieties, and this is due to a considerable variation in the productiveness of avocado trees. Some trees profitably bear fruits every year; others only in alternate years; others do not bear any fruit at all. Many varieties fail to bear fruits satisfactorily owing to lack of pollination brought about by the failure of the flowers to open at the proper time or to the incompatibility of the pollen itself. Generally, fruit bearing in avocado will be more successful if compatible varieties are interplanted and if their flowers open at such time as will permit cross-pollination, or if self-compatible varieties are planted, the opening periods of flowers overlap. However, the varieties to be interplanted should have approximately the same flowering time—early varieties should not be interplanted with late varieties and vice versa. The mid-season varieties can be interplanted with either the early or late varieties.

Of the hundreds of varieties now planted in the United States of America, not a single one has so far been selected that gives all the desired qualities. Each has some defects. And these varieties will have to be replaced eventually by a more desirable variety, or strain. In the Philippines, numerous seedlings and named varieties have already been imported and planted. Of those that have so far fruited, some are good, while others produce small fruits of poor quality. Moreover, many had failed to maintain themselves under local conditions. Altogether not less than 100 varieties and strains of avocado have already been introduced, out of which about 40 varieties are surviving and seventeen are bearing fruits. However, according to the list of avocado varieties given in the 1929-30 annual report of the California Avocado Association, there are 342 varieties, classified as follows: 62 Mexican, 78 West Indian, 152 Guatemalan and 50 unclassified. In addition, a score or more varieties and strains are fast developing in the United States of America and elsewhere. Therefore, aside from the varieties already found growing in the Philippines there are many more varieties and strains which merit further planting and introduction. Nevertheless, until new varieties, or strains, have proven to be superior and especially adapted to local conditions, the Philippine grown avocado varieties, which have fruited for several years, should be given preference in starting an avocado orchard. Of the many varieties that have been introduced and distributed, only a few have so far gained popularity. The Cardinal, Pollock, Lyon, Wester, Tertoh, Family, Cummins, Commodore, Cyrus, Quality, Douglas, Vega and Miami have fruited successfully in Lamao, Bataan and elsewhere in the islands. But due to the limited extent of their trial, their selection should not be considered final. The Cardinal has predominated, however, probably because of its productive habit under certain soil and climatic conditions.

When selecting the varieties to be planted, one should be guided by the following points: the trees should be hardy, productive, regularly bearing, disease and pest resistant, early or late bearing; the fruit should be of good flavour, quality and size; and the seed should be comparatively small. It should be borne in mind that the fat content does not indicate a good quality, for in the United States of America the most prized varieties are poor in this respect.

Requirements.

The avocado is distinctly tropical and subtropical in its requirements. There are now avocado trees growing in widely separated localities in the Philippines, and the behaviour of these trees clearly indicates that the plant is at home in this country. In localities where the dry season is not too long, they thrive with very little attention. However, when the dry season extends for four or five months, they require some irrigation unless the soil moisture is within the reach of the roots during the driest part of the year.

The tree is not exacting in its soil requirements so long as good drainage is afforded. It is very intolerant of standing water, and cannot endure it for any length of time. Deeply and well-drained soil, which is rich in organic matter, is the best for avocado, but well-drained heavy soil of average fertility will also grow good avocado, especially in moist regions. Any soil where citrus trees thrive will produce good avocado trees.

Like most other fruit trees, the avocado does not thrive well in places exposed to strong winds. Its leaves cannot quite resist excessively hot, dry winds. Besides, winds increase the evaporation of water which in turn may cause a heavy dropping off of immature fruits. Also the fruits are liable to suffer injury through rubbing against the branches or against each other, and the danger of the breakage of limbs, especially those heavily loaded with fruits, is increased. However, this is not a limiting factor in avocado culture, because it can be remedied by planting windbreaks in places where there is no natural protection from the winds. Windbreaks reduce the air movement and so diminish evaporation. Windbreaks should be planted around the orchard; if the plantation is large, windbreaks should be planted in every hectare lot.

The West Indian varieties are very tender, and are best adapted to low and medium elevations up to 900 metres above sea level. The Guatemalan varieties are rather intermediate, and have wider range of adaptability. They can be grown from sea level up to an elevation of 2,500 metres, but an elevation of not more than 700 metres is the best. The Mexican varieties are the hardiest with respect to cold weather, and have a wide distribution. They thrive best from 600 metres upwards.

Propagation.

The avocado is propagated by seeds, by budding, grafting, inarching, or marcotting, but preferably by budding or grafting. Inarching and marcotting are too laborious and expensive. Grafting sometimes gives a better result than budding. The grafted plants are oftentimes more vigorous than the budded ones. On the other hand, trees grown from seeds usually do not come true to type. The chances of obtaining a fruit of better quality than that produced by the parent tree are very slim. It is the experience of avocado growers that seeds are unreliable means of reproducing a variety. However, if seeds have to be depended upon for the propagation of avocado, the seed of some avocado varieties may be carefully halved so as to produce two plants from each seed. The resulting plants, however, should be given a reasonable dose of fertilizer in order to produce good growth. Generally, the whole seed germinates earlier, and the resulting seedlings are more stocky and have more number of leaves than the halved seed.

The first step in the production of budded or grafted trees is the raising of the stock plants. In the United States of America the varieties of the Mexican type are commonly used as stock plants because of their greater hardiness against frost than the large-seeded and hard-shelled varieties in spite of the greater amount of plant food in the seed of the latter. But this type possesses a wide range of variability, and caution should, therefore, be taken in using it as a stock plant in the Philippines. On the other hand, the West Indian seedlings, being generally more vigorous than the other types, may prove good stock plants at lower altitudes in the Philippines, although they were proven less successful as scion for the Mexican stock. The Guatemalan type will succeed both the West Indian and the Mexican stocks. This type is vigorous and thrifty, but somewhat tender, although less so than the West Indian. Fuerte, a hybrid between Guatemalan and Mexican types, is much used as stock plant in the United States of America nowadays.

As the seed of the avocado loses its vitality quickly, it should be planted while it is still fresh. And if the seeds cannot be planted at once, they should be stored in properly moistened sand, sawdust, charcoal, or sphagnum moss. The seeds may be planted directly in bamboo pots or in seed beds with the pointed end up. About one-fourth of the seed should be left exposed so that the resulting sprouts can be thinned out, leaving the strongest one. Set the seeds 40 or 50 cm. apart in the seed beds. In potting, the soil should contain one-third each of sand, loam, and well-rotted compost. If sown in seed beds, the soil need not be so rich—a sandy loam soil being sufficient. It is sometimes advisable to grow the seedlings for budding or grafting in the seed beds although it will require more labour to remove them properly when transplanting them in the field. Seeds should not be allowed to dry out, otherwise they will lose their viability.

Budding or grafting is done in the same way as in citrus or other fruit trees. It can be done any time the stem of the stock plants has attained the size of a little larger than a lead pencil provided it is not raining and that the seedlings are in condition, that is, the sap is flowing freely. The scion should be selected from the best tree of the desired variety, should be well matured, preferably from twigs which are just ready to send out a new growth, and should contain plump and well-developed buds.

Avocado stem is very brittle so that in forcing the bud to grow, a notch should be made of a few inches above the bud instead of cutting the stem half-way into the wood of the stock for lopping as in the case of other fruit trees. In lopping never bend the stock as in other fruit trees in order to avoid a premature breaking.

When the scion is already well advanced the top of the stock may be cut off entirely about 10 cm. from the bud. After the bud has grown to a length of about 25 cm., the stock should be cut off clean just above the union of the stock and the scion, and the cut surface should immediately be painted with white lead or other suitable materials. This will protect the wood from decay.

Planting.

When the plants are about 50 cm. high or more, they can be transplanted in the field at the beginning of the rainy season, at a distance of about 8 to 10 metres apart in holes large enough to accommodate the plants. Set the plants as deep as they grow in the nursery, and use good surface soil for refilling the holes. The soil should be packed firmly around the plant. It is well to pour in water while firming the soil. If water is available, planting may, of course, be done late in the rainy season, and even during the dry season. In transplanting, great care should be taken so as not to injure the root system, which is very delicate, and the roots should never be exposed to dry, or else the plants will die. To avoid the least injury to the roots, the plant should be dug from the nursery with a ball of earth. In planting balled trees, it is necessary to remove the sack or wrapping materials from around the ball of earth, as the sack will decay in due time. However, to facilitate the rotting and the penetration of water, two or three cuts should be made at the sides with a sharp knife. Split and remove the pot in transplanting the potted plant. Cut one-half of the leaves or young twigs of the plant previous to transplanting. The newly-transplanted plants should be watered and mulched from time to time as may be necessary. In watering, a basin should be made around the tree to hold the water. Shedding the newly-transplanted plant is necessary if planting is made during the dry season. Care should be taken that varieties are planted together, which will provide for each other at the time when each is ready for pollination.

Orchard Management.

A modern fruit orchard should be well cultivated, irrigated, fertilized, cover-cropped, pruned and mulched from time to time. The cultivation of young avocado orchard is done in the same way as in citrus, that is, deep ploughing is advisable at the beginning; but when the trees are already big, deep cultivation should be avoided as much as possible, otherwise there is danger of destroying part of the root system and exposing the soil. At this stage the tree can be kept clean by occasional hoeing of the ground near its trunk. Mulching the trees and planting cover crops between the spaces are beneficial for the upkeep of the trees, since both prevent soil erosion and replenish the nitrogen and organic matter of the soil. Legumes have the power of gathering free nitrogen from the air and storing it in their nodules, and are, therefore, more valuable as cover crops than non-leguminous plants.

In order to get the most profit from the trees, it is always a good practice to maintain the fertility of the soil. To accomplish this, fertilizers should be applied regularly to bearing trees. There is a wide diversity of soil in the Philippines, so that to give advice regarding the kind and amount of fertilizer without knowing the condition of the soil is almost futile. However, the kind of fertilizer needed by avocado is probably not very different from that needed by other fruit trees, although the amount may differ. And in the absence of experimental data no definite and specific information is given. The condition of the tree and of the soil should be determining factor as to the kind and quantity of fertilizer to be used.

A young tree requires very little, if any, commercial fertilizer until it begins to bear fruit heavily. Animal and poultry manure and nitrogenous commercial fertilizers are, however, beneficial to young avocado trees. A complete fertilizer which is low in nitrogen and high potash is good for fruit-bearing trees. In the United States a mixture containing 5 per cent. nitrogen, 7 per cent. phosphoric acid and 2 per cent. potash, the nitrogen being derived from organic materials, has given good results on young trees when applied at the rate of 1 lb. per tree, three or four weeks after planting, and 8 to 10 lb. on five-year-old trees. The percentage of potash is increased while the trees come into bearing—5–8–3 or 6–6–3 in spring, 4–8–10 in the fall, and 4–7–5 or 5–5–5 in summer.

As a general rule, avocado requires little or no pruning at all after each tree is properly established. However, inasmuch as the avocado plant is naturally weak and brittle, the pruning of forking branches and shortening of young and spindling twigs may be done to strengthen the stock and the framework of the growing trees. This is to be done at their dormant stage. The mere pinching of undesirable shoots may induce the growth of other buds where an extension is needed in order to make the trees more or less symmetrical in growth. Tall-growing trees should be pinched back. Again, some thinning of the branches should be done from time to time so as to permit sunlight to the inside foliage. Of course, any heavy pruning should be avoided, as this will greatly accelerate the vegetative growth and delay the fruiting period. Only dead and undesirable branches should be removed after the fruits have been harvested. All wounds should be painted with white lead or other suitable materials to avoid rotting.

In places where there is a uniform distribution of rainfall, the avocado need not be watered at all, but in places where there is a prolonged dry period watering is necessary unless the ground water is high or is within the reach of the roots. The water may be distributed in the way which is most convenient, economical, and effective. The furrow system of irrigation should be practised on big plantations whenever it is practicable for the sake of economy, and the bucket system may be used for watering the individual trees around the house. Where there is lack of water in the soil, the trees may shed much of their foliage, flowers or fruits.

It is often advisable to top-work undesirable trees in the orchard to a good variety. This can be done by cutting the tops back, including the big branches. Of the numerous sprouts which appear, only a few good ones should be left for budding or grafting with selected scions. The cut surfaces and the trunk should be painted and whitewashed in order to protect them from decay and sunburn.

Pests and Diseases.

There are comparatively few insect pests and diseases which at present affect the avocado in the Philippines. Among the insects, the borers and the scale insects, including mealy bugs, are found destructive to our avocado trees. Other pests are the thrips, caterpillars and white ants.

The borers are found to attack the trunk, pith and twigs. They work their way downward, destroying all growth thereby, and may eventually kill the tree. Limewash may lessen the infestation.

The caterpillars attack the leaves and flowers. They can be controlled by spraying either with lead or calcium arsenate.

The thrips attack the flowers, but they can be prevented by dusting with pyrethrum, derris powder or tobacco dust.

The scale insects suck the sap of twigs, leaves and fruits. Heavy infestation weaken the tree, and sometimes cause premature falling of fruits. Oil emulsions and soap-suds are usually effective in controlling the scales.

The important diseases of avocado are die-back and anthracnose. The anthracnose is a disease of the leaves, bark, and fruit. The affected portions turn black with sunken spots, usually circular in form. It can be controlled by spraying with Bordeaux mixture. The infected parts should be cut and burned.

The die-back is a disease of the twigs. The infected parts become dry. It can be prevented by spraying the trees with lime sulphur or Bordeaux mixture. These sprays should be applied periodically once every two weeks at least, as the new flushes appear until they mature.

Other diseases of minor importance which may also be controlled are the scab and the leaf spots.

Harvesting and Yields.

The avocado season in the Philippines is from January to March and from June to September, depending upon the climate of the locality. In humid districts the season is rather early. There are, therefore, only two short periods in the year during which avocado fruit is not obtainable in the market—from April to May and from October to December. However, by planting varieties which fruit at different times of the year, it is possible to produce avocado fruits all the year round. In the United States the Fuerte variety is said to be fruiting from November to May; Verde from March to May; Puebla from November to December; and Taft from May to November.

Avocado trees grown from seedlings begin to bear fruits when about four to eight years old, six being the average. On the other hand, vegatively-grown trees sometimes begin to bear fruit the first year in the nursery. At this age, however, and probably up to three years, they should not be allowed to fruit at the expense of the future growth and vigour. The annual yield of a full-bearing tree ranges from a few to 500 fruits—sometimes from 800 to 1,200 fruits. An average of 500 fruits a year per tree is considered a fair yield. Generally the yield varies from one season to the next, partly depending upon the size of the previous crop, rainfall, winds, and the condition of the tree at the flowering season.

The avocado fruits are very perishable and should be handled with care. In harvesting, the fruits should be carefully clipped off, leaving a short stem on them for handling purposes. A fruit-picker provided with a knife similar to that one used in picking the mango fruits should be used in harvesting the fruits of tall-growing trees. Furthermore, the avocado should be harvested when fully matured, and not allowed to ripen on the tree. The maturity of the fruit is indicated by its colour. For example, the appearance of reddish streaks in the case of purple-fruiting varieties and the change of colour from green to a lighter green in the case of green varieties are indications of maturity. In the thin-skinned forms the ripeness of the fruit can be determined by external pressure, but in the very thick-skinned varieties this cannot be done. The ripeness of the fruit of the latter vareties can be determined by the stems when it is easily pulled out of the fruit, and when a toothpick can be easily pushed through the stem it indicates that the fruit is ripe enough for eating. If the fruit is picked before reaching maturity, its flavour is poor, while, if left too long on the tree, the keeping quality is impaired. The fruits should be placed in a basket or box lined with packing materials, such as dried straw, banana leaves, &c., when intended for short distances shipment; when the fruits are to be shipped long distances they should be wrapped individually with soft tissue paper.

Uses.

The avocado fruit is rich in fat and protein, but low in sugar content. Its oil is similar to olive oil, and can be used for the same purposes. It has been known in countries where avocado has been long grown that its fruit is a wholesome and highly-digestible food. Wolfe and others said that an ounce of avocado contains about 73 calories, which is nearly three times that of banana, one and a half times that of beefsteak and other meats, and three times that of several kinds of fish. And, because of this and its low carbohydrate content, it is a good food for diabetic people. Its iron content is about three times that found in other common fruits, and, therefore, it is a good food for anæmic people.

In the Philippines the fruit is eaten with sugar and milk, or in frozen form, or as ice-cream ingredient. Few people eat the meat offhand. In the United States it is extensively used as a salad fruit, because of its delicate, nut-like flavour, and its smooth, buttery consistency. The avocado should not be considered merely as a salad fruit, but as a substantial food which may be used in a great many combinations. For it is also eaten offhand, with the addition of lime or lemon juice, or salt, or sugar only. Mashed and seasoned, the meat is used as sandwich filling or is spread on salted crackers. Often it is also added to soup just before serving. A number of recipes on how to eat avocada fruit have been published from time to time.

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COCO-NUT OIL—PROPERTIES AND COMPOSITION.*

By R. Child, F.I.C., B.Sc., Ph.D. (Lond.), Director of Research and Technological Chemist, Coco-nut Research Scheme (Ceylon).

Coco-nut oil as ordinarily prepared in Ceylon and other tropical countries is a colourless to pale brownish yellow oil. In temperate climates it appears as a greasy, somewhat crystalline white to yellowish solid fat, which has a melting range of between 20° and 26°C. (68° to 79°F.). Unless refined it has a more or less pronounced odour of the coco-nut.

2. Composition.

Coco-nut oil is composed of the glycerides of volatile and non-volatile fatty acids with between 0.2 and 0.8 of non-saponifiable constituents. The latter, which are mostly of the nature of sterols, have not been recently investigated and will not be further considered here. Whatever the country of origin, coco-nut oil seems to vary surprisingly little in composition and is regarded as the least variable of the commercial fats.

Several analyses giving the percentage composition of the fatty acids (present as glycerides) have been published since 1925, when the modern technique of such analyses was first developed, and these show good agreement, the following table giving the range of figures obtained:—

	Per cent.	
Caproic acid	0.2 – 0.5	Saturated acids about 91 per cent.
Caprylic acid	7.8 – 9.0	
Capric acid	4.5 – 6.8	
Lauric acid	44.7 –51.0	
Myristic acid	16.5 –18.5	
Palmitic acid	7.5 – 9.0	
Stearic acid	1.0 – 3.0	
Oleic acid	5.0 – 8.2	Unsaturated acids about 9 per cent.
Linoleic acid	1.0 – 2.6	

Coco-nut oil, like palm kernel oil and the fats from certain other *palmoe* species, is thus characterized by the presence of a high percentage of lauric and myristic acids and notable proportions of the lower acids. This makes the oil eminently suitable as a butter substitute in margarine and the like.

3. Technical Analysis.

It is not possible to apply the exhaustive method of analysis, such as those leading to the above composition figures, for commercial purposes, neither is it necessary. Commercial methods of analysis are required for the purpose of confirming the identity of an oil, for detecting adulteration, for determining the quality of a sample (e.g., whether it is rancid or acid), and consequently for assessing its value for any particular technical purpose. Such methods are thus routine ones for specific purposes and must be quick and easily reproducible. More refined methods are usually only employed in fundamental research.

It is not the purpose of this article to go into details of methods of examination, but it is necessary to discuss briefly the principles of some of them.

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* From *Journal* of "Coconut Industries", Vol. 3, No. 2, June, 1939, pp. 86–91.

Physical methods of examination include the determination of the *density* of the liquid oil and of its *refractive* index, the latter being an optical measurement of the amount of bending (or refraction) of a ray of light passed through the oil. Such figures are often characteristic of particular oils. Thus the determination of the refractive index would detect in a few minutes the admixture of 10 per cent. of parings oil to white coco-nut oil.

Saturated and Unsaturated Fatty Acids.—It will be observed that in the table above the first seven acids are grouped as saturated, and oleic and linoleic as unsaturated. All of these fatty acids are chemical compounds of carbon, hydrogen and oxygen, differing, however, in the proportions of these three elements.

The acids grouped as saturated contain the maximum of hydrogen possible—they are "saturated" with respect to hydrogen. The unsaturated acids are capable by suitable chemical processes of taking up more hydrogen. Thus oleic acid can absorb hydrogen to be converted into the saturated acid, stearic. The unsaturated acids can absorb, besidese hydrogen, other elements, such as oxygen, chlorine, iodine, &c., and in practice their capability of absorbing iodine is used as a measure of their unsaturation, the iodine value of an oil being the number of parts of iodine which 100 parts of the oil can absorb under certain standard conditions. Thus pure oleic acid can take up about 90 parts of iodine per 100 parts; some samples of linseed oil can take up as much as 200 parts or twice their weight of iodine. Coco-nut oil has the lowest iodine value of all the oils in common use, the iodine value being between 7.5 and 9.0 for the majority of samples.

The iodine value indicates, then, the degree of unsaturation of an oil which, in turn, indicates broadly the technical use to which an oil may be put. Thus oils with value over 100 are classed as "drying oils", owing to their applicability in paints and varnishes; such oils rapidly absorb oxygen and are converted into hard, glossy films. Coco-nut oil falls into the non-drying class.

Saponification.—When oils are treated with alkali—say caustic soda or caustic potash—the fatty acids are set free from their combination with glycerine and combine with the alkali to form soap, the glycerine also set free forming a by-product of the soap industry.

Different oils require different characteristic amounts of alkali for this saponification. The number of parts of caustic potash required for complete saponification of 1,000 parts of an oil is known as its saponification value. Oils like coco-nut oil, which contain large proportions of lauric and lower acids (caproic to lauric in the case of coco-nut oil), have high saponification values. Coco-nut oil has, in fact, the highest saponification value (255 and over) of all the oils in common use, rape seed oil (170 approximately) being the lowest. The majority of common oils have values round 195.

The lower fatty acids, caproic to lauric, are somewhat volatile, particularly when treated with steam, and special analytical methods (*Reichert Meisel value* and *Polenske value*) have been based on this for dealing with oils containing lower acids, particularly coco-nut oil, palm kernel oil and butter fat.

Coco-nut oil,. owing to its cheapness, is seldom adulterated and the latter methods are seldom required for coco-nut oil itself. It is, in fact, with a view to detecting the addition of coco-nut oil to more expensive fats, especially butter, that they have been developed.

Free Fatty Acids.—One determination which is usually required in a technical examination of a fat is that of its free fatty acid content. All oils consist essentially of glycerides of fatty acids. These glycerine compounds can be split into their components—fatty acids and glycerine—in various ways. Saponification with alkali is one which has been mentioned. In the process of digestion of fats, the first stage is this splitting, which is affected by a digestive ferment or enzyme known as "Lipase". Such enzymes are present in the oil seeds themselves from which oils are derived; they are also secreted by moulds, &c. Consequently oils pressed from stale, mouldy copra or seeds, or which have been allowed to deteriorate in the presence of moulds or in other ways, are found to contain fatty acids in the free state, i.e., set free from their combination with glycerine.

The presence of free fatty acids is undesirable, particularly in edible oils; acid oils have to be refined for edible and some other purposes which results in losses amounting to about twice the weight of free fatty acids present. Note also that whilst the development of free fatty acid in an oil is not the same thing as rancidity, the two often go side by side, and an acid oil is likely to be a rancid one.

The determination of the percentage-free fatty acid in an oil is thus an essential one in the examination of technical oils. Older text-books refer to coco-nut oils coming into the market containing as much as 25 per cent. free fatty acid. Such low-grade oils are seldom met with to-day.

Ceylon-milled oil has the advantage of being pressed in the country of origin, i.e., of having available supplies of fresh undeteriorated copra. It is marketed in two grades, white oil and mill oil. (Parings oil is mentioned later.) Mill oil usually averages about 2 per cent. of free fatty acid; samples do not commonly exceed 3 per cent. White oil is usually below 1 per cent.—all percentages calculated as lauric acid.

British Standard Specification.—The British Standards Institution has issued a specification for coco-nut oil (B.S.S. No. 682—1935) which includes standards for moisture, colour, refractive index, iodine value (7.0-9.5), saponification value (not below 255), acidity (not above 5 per cent. as lauric) and unsaponifiable matter.

Edible Coco-nut Oil.—Has usually to contain below 0.10 per cent. free fatty acid (lauric), to be free from suspended impurities, to be sweet and neutral in taste and odour, and to meet fairly stringent standards as to colour. Further details are given in an article of the writer's in the *Tropical Agriculturist* (Ceylon), vol. 89, No. 5, 1937.

4. Parings Oil.

In the manufacture of desiccated coco-nut, the brown skin of the nut is removed. Drying and pressing of the skin or "parings" produces an oil differing somewhat from ordinary coco-nut oil. As usually produced, the iodine value lies between 19 and 25, and the saponification value between 237 and 244. The free acidity is usually rather higher than that of mill oil and, as would be expected, parings oil is usually darker in colour.

As would be deducted from the higher iodine value, parings oil has a higher content of unsaturated acids. No complete analysis of the component acids has, however, been made for commercial parings oil.

Parings oil sells at a slightly lower price than mill oil. Its annual production in Ceylon can hardly exceed 2,000 tons, and with the exception of the Philippine Islands it is probably not produced elsewhere.

5. Food Value of Coco-nut Oil.

The essential factors for maintenance of health and for satisfactory growth, besides water and oxygen, are proteins (which vary in biological value), fats, carbohydrates, certain mineral salts and vitamins.

Fats are either stored in the tissues or oxidized to produce energy, having from the latter point of view a value expressed in calories exceeding both carbohydrates and proteins.

All fats consist, as has been pointed out in the previous section, essentially of glycerides of fatty acids.

In general, any fat or mixture of fats which melts at about human body temperature is absorbed by the human organism with little difficulty. A very hard fat melting at, say, 50 deg. C., is not readily assimilated when ingested alone, but is so when blended with a soft fat in such quantity that the mixture is liquid at 37 deg. C.

There is no evidence that different glycerides have different food values. The mixtures of fats employed in margarine are blended to give a product whose melting point and consistency resemble butter, and, broadly speaking, there is no difference in the food value* between one such mixture and another, and from this point of view all fats or mixtures of fats may be regarded as equivalent if the limitation imposed by melting point be observed.

Recent work on the rate of digestion of fats has been published by Miss Hartwell, of King's College, London (*Biochem. J.* 1938, 32, 462), which seems to favour coco-nut oil in this respect. The rate of digestion of various fats by pancreatic lipase was measured, the fat being prepared in the form of "reconstituted creams" so that it was in the form of minute globules and the conditions comparable with those of actual digestion in the organism. The results are of particular interest and some of the conclusions worth quoting *in extenso*—

> "Coco-nut oil was digested more rapidly than any other fat, including butter. Almond oil, ground-nut, bacon fat, beef fat, oleostearine, cocoa butter, cod liver oil, cotton-seed oil, lard, mutton fat, olive oil, premier jus, soya bean oil, hardened whale oil and hardened ground-nut oil, were digested at a much slower rate than butter and all at approximately the same rate.
>
> It seems possible that if margarines contain this fat (coco-nut oil) they may be more rapidly digested than butter." Coco-nut oil "may prove a more valuable food than has hitherto been supposed."

VITAMINS.—Coco-nut oil has been reported to contain traces of vitamins A and E. It is, however, not a good source of vitamins and it is at least doubtful whether edible coco-nut oil which has undergone processes of refining contains any effective amount of any vitamin.

On the other hand coco-nut oil as a source of fat in the diet is *more satisfactory than other fats in economizing vitamin E*, some other fats such as lard apparently having an antagonizing effect on this vitamin. A similar statement has been made that coco-nut oil *"economises" vitamin B.*

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* That is, as fats. No consideration is given to accessory food factors such as vitamins, &c.

6. Rancidity of Coco-nut Oil.

Space does not permit of a detailed discussion of this subject. It will suffice to say that, contrary to statements in old text-books that coco-nut oil readily becomes rancid, it is when refined of good keeping qualities.

It is, however, under the action of moulds, liable to develop a type of rancidity common only to oils containing fatty acids below lauric, with the development of odoriferous ketonic substances. This type of rancidity is, therefore, known as "ketone rancidity", a "perfume rancidity". It cannot develop in oils kept free from moisture, sediment and moulds.

COCOA POD AND COCOA BEAN.*

The period of hardest work for the cocoa grower begins with the approach of the main crop. The ripe pods have to be picked and gathered and the cocoa beans, the actual material of the crop, have to be removed from the pods and prepared for the curing. As the pods ripen at different times, which means that the picking, i.e., of the main crop as well as of the mid-crop, lasts over several months, the working process is often repeated. Careful picking of the pods at the proper moment assures to a certain extent the quality of the final product, for only properly ripe pods can yield properly ripe beans.

The picker must have a good knowledge of the degree of ripeness of the pods in order to correctly distinguish between the over-ripe and unripe fruits.

The first work of the crop is the picking of the pods, i.e., cutting them off at their stems. The pods on the lower branches are cut off with a bush knife; for those on the higher branches cocoa knives are used (these vary in shape in the different centres) which are fastened to long sticks.

Great care has to be exercised in this kind of "picking"; there must be no damage to the trunk and branches or to places where flowers (and pods) begin to develop, for such damage would be injurious to future flowers.

The pods drop to the ground, and are then gathered and put in heaps; they are sorted, and, right on the spot, they are opened either with bush knives or sticks or by beating them on a stone.

This breaking of the pods lays open the seeds of the cocoa tree, the universally appreciated cocoa beans. From 20 to 70—on an average, however, 40 beans—lie in five, or at the utmost seven or eight, orderly rows from end to end, embedded in a thin film of soursweet, soft, white or pale pink pulp. The beans are about 2 to 3 cm. long and 1 to 1½ cm. thick. They are almond-shaped, and their colour varies between pale pink and pale brown tints.

The inside of the cocoa bean—the nibs—covered by a thin shell, consists almost exclusively of irregular, rather rifted-looking folds of seed-leaves—cotyledons—of a whitish or darker tint, which in some cases is even as dark as purple. The cocoa bean has no nutritive tissue, as met with in the seeds of other plants. This only appears in the form of a thin, colourless membrane, stunted in its growth, which surrounds the seed-leaves. The mass of the kernel is thus made up of the cotyledons, the seedbud of the cocoa bean. They contain all the nourishment which makes cocoa a most valuable product of tropical agriculture, a product which captured the world markets in a very short period. The production of cocoa, the trade in the article, the working-up, and finally the sale of the finished goods, has created an organization that is of utmost importance to the economy of all countries that share in it.

The cocoa beans are removed from the opened pods either by hand or with a scoop or with a wooden spatula. They are freed superficially from the sticky pulp and put into baskets or other suitable containers to be taken to the next stage of the work, the curing plant. The larger plantations even use a portable railway for this purpose.

At the curing plant the cocoa beans are turned into the commercial "raw cocoa". The large number of pods left over after the removal of the beans are dug into the soil to serve as manure. Pods which show any signs of disease (black rot) are generally burnt very carefully.

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* From *Gordian*, Hamburg, 10th June, 1939., XXXXV. Jahrgang, Heff Nr. 1059.

PRACTICAL COMPOSTING.*

A Plea for Adapting the Technique to the Raw Material and the Environment.

By G. B. Masefield, M.A. (Oxon.), A.I.C.T.A., Agricultural Officer, Uganda Protectorate.

The subject of making compost manures has received a good deal of attention lately, and a number of excellent accounts have been published describing systems of composting. The danger of these methods is that they tend to become too systematic; and, as one who has had experience of composting under varied climatic conditions, I feel that a word of warning against this tendency is desirable.

It is evident that composting cannot satisfactorily be reduced to rule-of-thumb methods. A system which is advocated for one place may be of little use in another with a different climate, and even from one season to another, with differences in rainfall, the same system will not prove satisfactory. For this reason, all systems which gave a "time-table" of composting operations are to some extent a snare and delusion. The experienced composter will vary his methods from season to season, and even from day to day. This is one reason why, to get the best results in large-scale composting, it is essential to have adequate expert supervision and not to rely upon unskilled native labourers only.

Pits or Heaps?

As an example of the need for flexibility, we may quote the much-vexed question of whether compost is best made in pits or in heaps. Pits are, of course, best under dry conditions, as the evaporation is much reduced; but they fail in wet climates or seasons. I have seen compost made in concrete pits without any provision for drainage; in a very wet season there was standing water in the pits and the lower layers of the compost putrified and became noxious. On the other hand, in very dry weather heaps may become so dried out that decomposition almost ceases and some of the material is actually blown away.

There are, of course, means of getting round both these disadvantages. I have made successful compost with garden refuse in a pit, the floor of which sloped down slightly to a drainage channel at one end. During a very wet season in Uganda, the rainfall just served to decompose the compost nicely without any addition of water, and the compost never became water-logged.

Heaps, on the other hand, can be conveniently protected from evaporation during dry weather by laying a few coco-nut palm leaves along the top to form a thatch. During the wet season a good idea is to build them with the top sloping inwards to a central hollow so that all rainwater is caught and collected. Whether compost is best made under a roof or in the open depends on the climate, and also on whether the water supply is sufficient to compensate for the rain lost by using a roof.

An experienced composter again will vary the size of his heaps, building them bigger in dry weather and smaller in wet. Another factor in which flexibility is desirable is the frequency of turning. In dry weather, excessively frequent turning leads to far too much loss of moisture. As an extreme example, I may quote an experiment in which two compost heaps were built, each containing at the outset 9 cwt. of fresh material. The experiment ran for three and a half months, during which one heap was turned weekly and the other not at all. At the end of that period, the unturned heap weighed 8 cwt., but the turned heap only 3 cwt.

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* From *Tropical Agriculture*, May, 1939, Vol. XVI., No. 5, p. 99.

This matter of control of moisture content is probably the most important single factor for success in composting, and too much insistence cannot be laid on frequent visits to the compost heaps and a flexible system which will take advantage of weather conditions.

The Fly Menace.

Another point to which great attention must be paid is the control of fly breeding in the compost. In most composts a sufficiently high temperature is reached in the interior of the heap to kill fly eggs and maggots. But the material at the edges does not reach this temperature, and, therefore, periodical turnings are necessary to ensure that this material is mixed up in the centre of the heap. In the case of the common house-fly, which is probably the commonest breeder in compost, the period from the laying of the eggs to the emergence of the fly averages about twelve days in the tropics. It is therefore essential that the heaps should be turned at least every ten days as long as the compost is fresh enough to attract egg-laying flies.

In any locality, it may be found that other species of flies are commonly breeding in compost. For example, in Trinidad *Leptocera ferruginata, Chrysomyza ani,* and an unidentified Tachinid fly were found to be of very common occurrence. Where this is so, the length of time from egg to emergence for each species should be ascertained, and the turning programme arranged accordingly.

Since flies breeding in compost may become a serious nuisance and in some cases a menace to the health of people or livestock, this is another reason for insisting that operations such as the turning of compost should be responsibly supervised. For the same reason, composting cannot be altogether recommended as an occupation for uneducated native peasants.

Materials for Composting.

In examining the suitability of different materials for composting, the chief consideration is to get the right degree of aeration in the mass. For example, maize stover for composting is better chaffed than uncut; but the chaff-cutter should not be set to cut too short, as this again leads to excessive compaction in the heap. Sugar-cane tops, being shorter, may be composted without chopping up. Rice straw, if composted by itself, becomes too compact and does not decompose. Pea and bean haulm are rather too open for composting by themselves, but are a good lightener for cereal straws. In composting garden refuse, care should be taken not to include too high a proportion of lawn-mower cuttings, as these tend to compact themselves and lead to anaerobic fermentation and acidity. Weeds are difficult to decompose if too much earth is included with their roots; but Beckley(1) has overcome this difficulty by growing beans on the compost heaps, which assists rotting.

In general, it may be said that there are few types of agricultural refuse which cannot be composted if the right degree of aeration is obtained. Probably all of them rot better if mixed with other suitable ingredients than in the pure state, a fact which seems to have been too much overlooked in estate methods of composting. One of the exceptions seems to be tobacco stalks, which are very hard to induce to decompose. I have also had poor results with plantain leaves and peelings, both of which are a common type of habitation refuse in Uganda.

In cases where adequate aeration of the compacted mass is hard to obtain, this may be achieved artificially by placing ventilating tiled (Lambert and Davis⁽²⁾) or lengths of bamboo pole under the heaps. Here again there is plenty of scope for ingenuity and flexibility of programme.

Experiments on Composting.

The technique of composting experiments has its own difficulties, which make it very hard to obtain results that are convincing to the modern statistically-trained critics. In a series of experiments carried out in Trinidad at the Imperial College of Tropical Agriculture on the effect of adding various substances such as dung, sulphate of ammonia, lime, and an inoculum of "activated compost" to composts with the object of accelerating decomposition, no results were obtained which reached statistical significance as to the benefit of any of these treatments.

One reason for this position is the difficulty of obtaining from a large and often heterogeneous mass of compost a small sample for chemical analysis which shall be representative of the whole. The statistically-minded may be interested to note that on two occasions, when taking six samples from the same point in the same heap for measurement of carbon dioxide evolution, the sampling error proved to be 190 per cent. and 227 per cent. of the mean respectively.

Another difficulty lies in finding a suitable means of measuring rates of decomposition. After some experience in endeavouring to assess this by such methods as temperature records, chemical analyses, degree of humification, carbon dioxide evolution, and fungus and bacterial counts, I have come to the conclusion that there is no better criterion than judgment by eye and hand. A very useful technique is to take a few fibres from the compost mass in one's hand and roughly feel the breaking strain, by which means one soon becomes quite proficient in judging the degree of the rotting. Eye and hand can take in the whole of the heap in a way in which sampling methods cannot, and can often deliver judgment which cannot be translated into figures.

Although it appears, therefore, that experiments in composting are apt to be disappointing, I think that there is a danger in the fact that most of the writers who have advocated different systems of composting have worked these out quite empirically, have not compared them side by side with other systems which have proved good, and have not investigated a number of variations which might have greatly improved the process. It seems desirable that a much greater number of field trials in composting methods should be made, which may at present be of great assistance to the practical man, but from which accurate scientific results should not be looked for too soon. In estate practice, it is better for every composter to make his own experiments rather than to follow too slavishly methods which have been worked out for other localities and climates.

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LIVESTOCK—ITS PLACE IN ESTATE PRACTICE.*

By R. Paton.

It is an axiom as old as the land itself that "you can't farm without muck" and never was this truth being more forcibly driven home than it is to-day. Throughout the length and breadth of Britain one is confronted with the depressing spectacle of derelict land, worn-out and impoverished pastures, former good hill grazings overrun with bracken, gorse and brambles rampant in what once were arable fields; and as a concomitant one hears the same tale on all sides of dwindling livestock. The cold blast of economic depression which has assailed the agricultural industry ever since the few prosperous years following the war has completely upset the established rules of farming practice, and farmers have been forced to adopt methods of working their land which are quite opposed to their natural instincts of good husbandry. As I heard it aptly described not long ago, "good farming no longer pays", but the man who said that did so with his tongue in his cheek, knowing full well that the account would have to be squared some day.

Tractors have taken the place of horses on many farms, mechanized transport has almost completely driven the horse from the roads, uneconomic prices for beef, wool and mutton have resulted in a great diminution of cattle and sheep, while pig numbers have also dwindled under pressure of imports of pig products from foreign countries. The net result of all this so far as the land is concerned is a colossal decrease in the amount of humus and urine, which constitute the very life-blood of the soil.

Now, with the shadow of war overhanging the world, the Home Government has awakened to the fact that the fertility of the land has been allowed to sink to such a low ebb that it could not possibly respond to intensive production of food crops, such as would be required in war-time, and so subsidies have been offered for treatment with slag and lime, and now a further grant of £2 per acre is being made for the ploughing up of worn-out grassland; not with the object of bringing it into immediate crop production, but with a view to improving the pasture and getting livestock back on to the land so that its fertility may be restored against the day when heavy demands may have to be made upon it. So far as I know this is the first time that the importance of livestock as a means of promoting and maintaining fertility of the soil against a national emergency has been given the official recognition it deserves. To make the scheme complete proposals relating to subsidies and marketing are either in hand or under consideration to ensure remunerative prices for all classes of livestock.

There may be a vast difference between farming practice at home in the temperate climate of Britain and estate practice in Malaya, but the principle governing soil fertility is exactly the same. The methods whereby fertility is obtained and maintained may also be different, but they boil down to the same thing in the end—humus. Centuries of farming practice have established the irrefutable fact that fertility cannot be maintained for any appreciable length of time without livestock, and I venture to predict that the same truth will be brought home to agriculturists in Malaya, sooner or later.

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* From *The Planter*, No. 7, Vol. XX., July, 1939.

That there are drawbacks, and prejudices, to livestock on estates, I am very well aware, but in this connexion, I would suggest that I speak from experience, that most of these drawbacks and prejudices arise from the haphazard methods under which cattle have been tolerated on estates up to the present time. Cattle and goats which the labourers may be allowed to keep, as a sop to the Labour Department or under the necessity of retaining a labour force, are a vastly different proposition as compared with herds which are maintained by the keenness and under the supervision of the manager for the benefit of the estate. Whether they are owned by the labourers or the estate makes little difference; it is the methods under which they are kept that count, and if their value to the estate is recognized to the extent that the manager takes a direct interest in them, it follows that they will be of correspondingly more value to the labourers. Livestock owned by the estate are not likely to show any direct profit at the present time on the livestock account, but with careful management they should show no loss, and properly worked there should certainly be an increase in soil fertility, with a resultant profit from increased crops.

Cattle, pigs, sheep and goats are all suitable for this country, but not all of them are suitable for every estate. Pigs, for instance, might be difficult on an estate with Malay or Javanese labour, and goats are a pest on an estate with young clearings.

Cattle.

The two chief reasons I have heard put forward against the keeping of cattle are—

(*a*) lack of grazing grounds;
(*b*) damage done by uncontrolled grazing.

As regards (*a*) I think that too much importance is placed on the necessity for grazing grounds. If fields could be provided with good pasture grasses, we would have the ideal conditions for cattle, but as the pastures simply do not exist, and our main object in keeping cattle at all is to provide manure, it follows that they should be stall-fed as much as possible under conditions that will ensure the maximum conservation of dung and urine. All that is necessary, therefore, is a shed having a good concrete floor, with channels to collect the dung and urine and convey it to a concrete pit, a small area set aside for exercising purposes with a good supply of drinking water, and an area for the growing of guinea grass. This latter can be either an area set aside for the purpose, or the guinea can be grown successfully on the edges of drains or terraces, thereby preventing soil wash as well as providing fodder.

Under these conditions cattle will keep well and healthy, uncontrolled grazing and its attendant evils will not exist, and the manure can be utilized to the best advantage. Where composting is being practised, the addition of manure and urine to the heap will both expedite the breaking down process and enhance the value of the compost. From a manurial point of view the urine is most important, and great care should be taken to see that this is not wasted. If it cannot be applied to the land direct, compost heaps are the best means of "banking" it, but such heaps should be protected from rain otherwise a lot of the value will be washed out of them. The greatest value is obtained from the manure if methods of handling it are directed towards the production of the biggest possible volume of humus, with the minimum of waste, and in actual practice many ways and means of achieving this object present themselves. The following suggestions, however, are put forward for what they are worth:—

(*a*) Collection of dung and urine in concrete sumps and direct transport to the field. In this case the liquid manure should be poured into trenches which have been filled with vegetable matter such as grass and weeds, cover crop, coco-nut husks, &c., and then covered over with soil. This method can be applied also to the planting hole in the case of young rubber.

(*b*) Collection as above and daily application to compost heaps which are afterwards dug into the soil.

(*c*) Composting in the cattle shed after the manner practised at home in the "reeds" and courts of the cattle-feeding countries. This is the ideal method of making farmyard manure, but so far I have not tried it in this country, and so I cannot say anything about it.

On coco-nut estates under grass and mixed covers the cattle need never be housed at all. A method which I have employed with a herd of cattle for the past few years, and which has given very good results, is to move them systematically through selected areas, tethering them to individual palms at night, ten successive nights at each palm. During the day the cattle graze in the same area, and the driving to and fro from cattle sheds to grazing grounds, which is the usual routine with herds belonging to the labourers, and which is a potential source of damage and trouble, is entirely eliminated.

A good way to start off an estate herd is to purchase from 15 to 20 of the best young heifers available, and these can be picked up at about 20s. to 30s. a head. When they are two years of age a selected bull should be added to the herd, and thereafter the normal increase should be one calf per cow per annum. Bull calves should be castrated, unless required for breeding purposes, and all the calves should be allowed free access to their dams. A good cow at home will produce enough milk to rear two or even three calves, but in this country the average cow has barely sufficient milk to make a good job of one. And even then, in the hands of native dairymen and estate labourers, the calf has to be content with what it can get after the cow has been milked very nearly dry. It will be appreciated, therefore, that estate herds allowing the calves all the milk would very soon effect a great improvement in the standard of cattle throughout the country.

A herd started by the purchase of young animals need not entail a very big outlay, and after the first year or two the capital value should more than double itself. For about 30 animals, one or two herdsmen, according to whether the cattle are stall-fed or not, are sufficient, so the monthly expenditure is the amount of their wages only, and after a few years there should be sufficient revenue from sales to more than cover this. The handling of the manure, of course, is a direct charge to manuring, and the amount of labour required will depend on circumstances. That this will pay for itself, however, in terms of increased fertility leaves no room for doubt.

Pigs.

As compared with cattle, pigs require much more supervision and management if they are to be reared successfully. Here again manure should be the main consideration, but during periods of very low prices there is apt to be a deficit in the working account which will make the manure look rather expensive. It must be borne in mind, however, that where the pigs are properly fed the manure is much more valuable than that obtained from cattle, on account of the high proportion of concentrates included in their rations. A good feeding mixture contains broken rice, rice bran, coco-nut cake, and ground-nut cake, whereas cattle, as a rule, get no concentrates at all.

A herd based on 20 to 30 breeding sows will mean about 200 to 300 animals of all ages always in stock, and this a unit which can be handled efficiently by three coolies for the actual cooking, feeding, cleaning, &c., and attention to sows at farrowing.

Cross-bred animals, viz., strains obtained by mating pure-bred boars to local sows in the first place, and then breeding from the cross-bred sows again with a pure-bred or suitable cross-bred boar, pay best as they inherit the virtues peculiar to both in respect of stamina, rapidity of growth, prolificacy, abundant milk and resistance to disease. It has been proved by experiment and confirmed in practice that litters of cross-bred pigs are considerably heavier than Chinese pigs at time of weaning, and that the live weight gain thereafter brings the cross-breeds to a killing weight of about 120 katties anything up to two months earlier than the Chinese breeds, with a much better carcase.

It has been proved also that sows of the European breeds are not such good milkers in this country as Chinese sows, hence the necessity for retaining a proportion of native blood. Cross-bred sows of large white, middle white and large black strains, all of which have been in this country, are usually prolific breeders and good milkers.

Exercise is essential to keep breeding stock in good condition, and it is advisable to let young pigs and weaners have free range for an hour or two each day until they are four months old. If due consideration is given to this requirement when the site for the piggery is being selected, no great harm or trouble should result, and a small herd-boy put in to look after the pigs while they are out can keep them from straying into areas from which it is desirable that they should be excluded. Young clearings and nursery areas should be definitely forbidden, but there is very little damage that pigs can do in old rubber. When tapping is in progress, and the cups are fairly low down on the trees, pigs, of course, should not be let out until after the latex has been collected, otherwise a certain amount of crop is liable to be lost.

With training and close supervision Tamils make excellent pig-men, so there need be no difficulty on account of labour. A certain amount of foodstuffs, such as tapioca roots and sweet potatoes, can also be grown if land is available, and it may be possible to give such land out in the form of allotments to the labourers and then buy the produce from them. This provides work for dependants and enables them to earn a small income, thereby easing the strain on the family budget and at the same time contributing something towards improving the position as regards locally-produced foodstuffs.

One method whereby a herd of pigs can be started easily is to purchase, say, ten to fifteen in-pig gilts, preferably of a good cross-bred strain and in pig to a pure-bred boar. This forms the foundation of a good herd which can be built up to whatever size is desired. The gilts should all farrow within two or three months of taking delivery, and when the young ones are ready for weaning a suitable boar should be purchased with which to carry on the breeding.

The manure from the piggeries should be conserved in as concentrated form as possible and to this end a concrete sump should be provided to receive all the washings from the pens. Rain water from the roof should not be allowed to enter the sump as otherwise the manure will become too highly diluted. The pigs too, particularly the fatteners from which the best manure is obtained, should be housed fairly intensively so that the manure is not overdiluted by the washing of the pens. By this it is not meant that the animals should be overcrowded but the buildings should be designed so that the biggest possible concentration of manure is conveyed to the sump with the minimum of washing. One hundred and twenty fattening pigs housed in ten pens, each pen having a floor space of 10 feet by 8 feet under cover and 15 feet by 8 feet uncovered, will keep a sump 6 feet square full of good rich manure. The sump should be allowed to fill up and thereafter the quantity removed each day should be just more or less the amount which goes into it.

The manure as it comes from the sump is, of course, in semi-liquid form, and it has, therefore, to be transported in drums or buckets. In this form it is very suitable for applying direct to coco-nut and oil palms by pouring it in a circle at a radius of about 8 feet around each palm. The quantity required will depend on circumstances, but it is better to err on the side of being too liberal than otherwise.

Other ways in which this manure can be usefully applied are—

(*a*) *Nurseries.*—Periodic waterings with a fairly dilute mixture applied between the rows, preferably after a light chipping of the soil, will keep the seedlings making good healthy progress. Heavier dressings will promote rapid growth when it is desired to force on the seedlings for any special purpose.

(*b*) *Basket Seedlings.*—Two or three applications of a fairly weak mixture spread over the time between planting in the basket and removing it to the fields will ensure good, strong plants which will go ahead without any check.

(*c*) *In the Planting Hole.*—By filling the holes with soil to within 9 inches of the top and then applying a bucket of manure to each hole about two weeks before completely filling the holes and planting, some very fine results have been obtained both from basket seedlings and budded stumps.

(*d*) *Young Rubber.*—Seedlings and budded rubber will both rapidly respond to applications made in the field, and care has to be exercised to avoid over-manuring as it is likely to promote a bigger development of branches and foliage than the young plant can support. Unfortunately, a luxuriant growth of weeds is also encouraged, but can be depressed by planting a mulch of bush prunings or other cover crop around the plant, at the same time the mulch rapidly breaks down under the influence of the manure to form a rich, crumbly mould.

As regards the economics of pig-keeping it must be emphasized that present-day prices allow of no margin of profit on the pig-keeping account. Anyone who adopts this form of livestock must concentrate, therefore, on making revenue as nearly as possible equal expenditure and be prepared to charge any loss there may be to enhanced fertility of the land. It must be emphasized also that any cutting of expenditure in regard to feeding and the production of manure can only result in disappointment. In this connexion I cannot refrain from remarking that, in my opinion, it is a pity the Government does not do more to encourage this form of animal husbandry by restricting the import of pigs from other countries.

Sheep.

Where conditions are suitable, that is to say, wherever there are areas under grass, sheep do very well and are well worth keeping. They exhibit no tendency to stray, are very easily herded and therefore constitute no menace to growing crops.

A flock of Kelantan sheep was started on this estate some 25 years ago, and it is still going strong. Numbers are maintained round about 100 and for the past ten years Calcutta rams have been used for breeding purposes. Some difficulty exists now, however, in getting rams from India and some other breed will have to be tried.

Of all the animals with which I have had experience in this country, sheep are the least troublesome, and the following few points are the only ones which have to be observed:—

In the first place, they must be housed at night in a shed raised 2 or 3 feet above ground level and the floor of the house must be slatted to ensure that all the dung and urine will drop through. The ground beneath should be concreted and sloped to a concrete tank in which all the manure is collected.

The second important point is that the sheep should not be turned out in the mornings until well after the sun is up, and they should not be also housed again until just before dark in the evenings.

One or two rams only should be retained, according to the size of the flock, and allowing one ram for about 30 to 40 ewes. All other ram lambs should be castrated while they are still very young. From the age of one year all the sheep should be clipped periodically. The wool also is a valuable manure and should not be wasted.

No feeding of any kind is required other than grass, but a trough of good clean water should be available near the shed. Wet or swampy grazing grounds should be avoided and conditions around the shed kept clean and dry.

The amount of manure produced by a flock of 100 sheep is surprising and it is very highly concentrated and therefore of considerable manurial value.

With a Tamil labour force a flock of sheep is a decided asset also from the point of view of supplying fresh mutton on occasion and revenue from this source is generally sufficient to cover expenditure.

Goats.

Generally speaking, goat-keeping should follow the same methods as those outlined for sheep, but special pens should be provided for the entire males. Bunches of green bushwood should be hung up in the sheds at night, otherwise the animals are inclined to gorge themselves when they are turned out in the morning and suffer colic and other digestive troubles in consequence. Grazing grounds are essential and for this purpose light "belukar" or abandoned areas are ideal. Wet and swampy places should be avoided.

In the case of both cattle and goats the animals may be all owned by the labour force, but to get the benefit of them the sheds should be provided by the estate so that the manure may be properly conserved. The advantages of this system are apparent to any manager who realizes the importance which the ownership of livestock plays in the establishment of a settled labour force.

Having dealt now with a brief outline of how these four classes of livestock may be kept to the benefit of any agricultural holding, there remains one other point—disease. This must always be a risk where livestock is concerned, but with common-sense methods of housing, feeding and attention there is no reason why undue losses should occur on this account. Cleanliness and the avoidance of over-crowding are of first importance, and these are both possible of attainment on any estate. Immediate isolation of any animal which appears to be off colour is also easily arranged, and is only a common-sense method of avoiding trouble. To the same end any new animals which are being added to the herd should be kept apart from the others for at least three weeks. Digestive disorders all arise from faulty feeding and supervision alone will prevent this.

Overcrowding is a source from which various ills arise. Not least of which is infection from intestinal parasites. Badly designed houses also give rise to ailments such as rheumatism, particularly in the case of pigs, for which a dry sleeping place is absolutely essential.

More serious diseases, such as foot and mouth disease and swine fever, must not be lost sight of, but the risk of these is also minimized by strict adherence to the rules of cleanliness and quarantine. In case of doubt or definite outbreak, the Veterinary Department can be relied upon to take the necessary steps for treatment and control. In all cases, however, prevention is better than cure, and if this is borne in mind from the outset, the risk of disease should not prevent anyone from going in for livestock.

As regards housing, feeding and general management, the Department of Agriculture has already issued some excellent articles and anyone following these will not go far wrong.

In conclusion, I would emphasize the point that cattle manure alone will not work miracles, nor will it oust artificial fertilizers from their place in agriculture. Used in the proper manner, however, under conditions of correct soil management, it will so enrich the soil in humus and bacterial activity that the response to any other form of manuring or cultivation will be materially increased. The bounty of the "good earth" is there for our winning, but only as we nurture it shall we reap the reward.

AGRICULTURAL AND FORESTRY RESEARCH IN LATIN-AMERICAN REPUBLICS.

Scientific research is being recruited to the aid of the United States Government's programme of advancing its announced "good neighbour" policy in its relations with the other republics of this hemisphere to the status of mutual helpfulness among them in the fields of agriculture and forestry.

Of the approximate $1,000,000 designated for the promotion of closer cultural relations with our neighbours to the south, more than a third—or $350,000—has been allotted to the Department of Agriculture, for the purpose of a long-range research looking toward increasing the production in tropical America of raw materials needed in this country and now obtained principally from the Old World tropics. Some of the most important of these, notably rubber and quinine, actually originated in South America, but their present production is controlled by other countries in south-eastern Asia and the East Indies.

Preliminary steps will be discussed at the Lima conference, and in the meantime Department of Agriculture scientists are developing an agenda of projects to be undertaken. Expenditure of the $350,000 breaks down into support of several lines of activity, all regarded as highly important.

For four new Department of Agriculture attaches, $120,000 a year will be needed. At present this country has only one agricultural attache in the entire Latin-American area, with an office in Buenos Aires. The new men will be located in Mexico City, Havana, Rio de Janeiro, and Panama.

A survey of hardwood forest products of tropical American republics calls for $65,000 a year. At present virtually nothing is known about the economic possibilities of tropical American forests. A similar survey of soils, vegetation, climate and other factors affecting agriculture will take another $65,000 a year. Rubber and quinine will receive special attention under this project. The sum of $75,000 is set aside for the development of a tropical forest experiment station in Puerto Rico to work out problems and serve as a research centre for the Caribbean region. The United States Weather Bureau will be given $15,000 to make possible the training of meteorologists from American republics interested in special lines of weather forecasting technique. Particular attention to problems connected with hurricanes will be called for in this work. Finally, $10,000 is made available for the printing of scientific bulletins and other publications after translation into the three languages of Latin-America, Spanish, Portuguese and French.

Other lines of activity for which additional appropriations are not at present needed are the loan of agricultural officials to the American republics, co-operation with radio companies for the transmission of information, and promotion of the early completion of the Inter-American Highway as far as Panama.

Although the whole subject is only now being formally broached, informal inquiries by representatives of certain other American republics indicate their keen interest, and even eagerness to co-operate by placing their scientific facilities and tracts of land at the disposal of the scientists, both American and from among their own nationals, who will take part in the work.—Frank Thone.

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* From *Science*, Supplement, 16th December, 1938, p. 9. Vol. 88, No. 2294.

TABLE OF PLANTING DISTANCES.*

The following table shows the number of plants to the acre at distances of 1 to 50 feet apart, and the area in square feet available for each plant:—

Distance apart in feet.	Area for each plant in square feet.	Number of plants to acre.	Distance apart. Feet.	Area for each plant in square feet.	Number of Plants to the acre.
1 by 1	1	43,560	15 by 15	225	193
1½ by 1½	2¼	19,360	16 by 16	256	170
2 by 2	4	10,890	17 by 17	289	150
2½ by 2½	6¼	6,970	18 by 18	324	134
3 by 3	9	4,840	19 by 19	361	120
3½ by 3½	12¼	3,556	20 by 20	400	108
4 by 4	16	2,722	22 by 22	484	90
5 by 5	25	1,742	24 by 24	576	75
6 by 6	36	1,210	26 by 26	676	64
6 by 7	42	1,037	28 by 28	784	55
7 by 7	49	889	30 by 30	900	48
8 by 8	64	680	32 by 32	1,024	42
9 by 9	81	537	35 by 35	1,225	35
10 by 10	100	435	37 by 37	1,369	32
12 by 12	144	302	40 by 40	1,600	27
13 by 13	169	257	45 by 45	2,025	21
14 by 14	196	222	50 by 50	2,500	18

For numbers not given in the above table, divide 43,560 by the square of the distance apart the trees are required to stand, in feet; the result is the number of plants required per acre.

HOW TO DESTROY RATS.

Rats, at times, do get into a house or an outhouse, however carefully kept, and the housewife is naturally keen on keeping the pests away, or of getting rid of them when they appear.

Here are a variety of ways found useful, and such as can be dealt with by all womenfolk.

When a house is infested with rats which refuse to be caught by cheese and other baits, a few drops of the highly-scented oil of rhodium poured on the bottom of the trap will be an attraction they cannot refuse.

Place on the floor, near where rats' holes are, a thin layer of moist caustic potash. When the rats travel on this it will cause their feet to become sore, which they lick, and their tongues become likewise sore. The consequence is that they shun this locality, and seem to inform all the neighbouring rats about it, and the result is that they soon abandon a house that has such a preventive.

Cut some corks as thin as wafers and rub them in grease. Place the same in their tracks; or a bit of sponge dipped in treacle or honey, with a small quantity of oil of rhodium, will fasten to their coats and cause them to depart.

If a live rat be caught and smeared over with train oil, and afterwards allowed to escape in the holes of other rats, it will soon cause all to take their departure.

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* Extract from *Tropical Planting and Gardening*, by H. F. MacMillan, page 51.

Take a pan about 12 inches deep and fill it with water; then sprinkle some bran on the water and set the pan in a place where the rats most frequent. In the morning you will find several rats in the pan.

Make two parts of common squills (well bruised) and three parts of finely-chopped bacon into a stiff mass, with as much barley meal as may be required, and then bake in small cakes and put for the rats to eat.—*The Planter* and *Tanganyika Advertiser,* April, 1939.

HOW WEATHER NEWS IS COLLECTED.*

One of the many duties of the British Royal Air Force of which the general public is not aware is the maintenance of a special flight of pilots, known as the Weather Flight or, more ceremoniously, the Meteorological Flight. These pilots ascend daily to heights of about 25,000 feet to gather information of vital importance to the Air Ministry's experts when they work out their weather forecasts.

A knowledge of the weather conditions he is likely to meet is essential to the pilot who has to keep to a time schedule on regular routes, and the highly-organized weather service now operating co-ordinates information received from a network of ground stations observing weather conditions on land, from ships as they move about on the oceans, from pilotless balloons, whose behaviour as they rise in the air is being observed and interpreted by meteorological experts, and from aircraft reporting what happens in the upper air.

The Royal Air Force Meteorological Service Branch was established in 1924, since when the flight has carried out almost continuously its onerous duties; the occasions when the pilots have been prevented by bad weather from going up have been extremely rare. The last occasion when they had a "day off" was in November, 1936, when all Britain was hidden in a blanket of fog and not a single aerodrome could be seen from the air. Since then the flight has completed 1,500 high-altitude flights in unbroken succession, soaring to heights where in winter time they often encounter temperatures of 80 degrees below freezing point.

NOTES ON COPRA.†

Copra dried to 6 to 7 per cent., if stored in a well-ventilated dry store at an even temperature, will not seriously deteriorate. It is apparent that there is little to gain by drying copra much below 6 per cent. moisture content, although in the past much more stringent recommendations have been made.—*The Tropical Agriculturist,* Vol. 89, No. 5, 1937.

As usually shipped in the East, copra is attacked in transit by moulds and insects, resulting in serious losses and deterioration. Experiment had shown that it can be dried to such an extent that moulds and insects do not touch it, and that the resultant short weight is amply compensated by the absence of loss. This is not yet fully appreciated, but undoubtedly will be in time.—Supplement to *United Empire,* August, 1938.

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* Extract from W.740, Weekly London Letter by Andrew Blackmore, 1939.

† From *Agricultural Journal,* Department of Agriculture, Fiji, Vol. 10., No. 2, 1939.

PHASES OF THE MOON, 1940.

RABAUL.

January	2—Last Quarter	2.56 p.m.
	9—New Moon	11.53 p.m.
	18—First Quarter	4.21 a.m.
	25—Full Moon	9.22 a.m.
	14—Apogee	10.0 p.m.
	26—Perigee	9.0 p.m.
February	1—Last Quarter	12.47 a.m.
	8—New Moon	5.45 p.m.
	16—First Quarter	10.55 p.m.
	23—Full Moon	7.55 p.m.
	11—Apogee	12 noon.
	24—Perigee	8.0 a.m.
March	1—Last Quarter	12.35 p.m.
	9—New Moon	12.23 p.m.
	17—First Quarter	1.25 p.m.
	24—Full Moon	5.33 a.m.
	31—Last Quarter	2.20 a.m.
	9—Apogee	3.0 p.m.
	23—Perigee	8.0 p.m.
April	8—New Moon	6.18 a.m.
	15—First Quarter	11.46 p.m.
	22—Full Moon	2.37 p.m.
	29—Last Quarter	5.49 p.m.
	5—Apogee	7.0 p.m.
	21—Perigee	5.0 a.m.
May	7—New Moon	10.7 p.m.
	15—First Quarter	6.51 a.m.
	21—Full Moon	11.33 p.m.
	29—Last Quarter	10.40 a.m.
	3—Apogee	9.0 a.m.
	19—Perigee	5.0 a.m.
	31—Apogee	3.0 a.m.
June	6—New Moon	11.5 a.m.
	13—First Quarter	11.59 a.m.
	20—Full Moon	9.2 a.m.
	28—Last Quarter	4.13 a.m.
	15—Perigee	1.0 a.m.
	27—Apogee	9.0 p.m.
July	5—New Moon	9.28 p.m.
	12—First Quarter	4.35 p.m.
	19—Full Moon	7.55 p.m.
	27—Last Quarter	9.29 p.m.
	10—Perigee	5.0 a.m.
	25—Apogee	3.0 p.m.
August	4—New Moon	6.9 a.m.
	10—First Quarter	10.0 p.m.
	18—Full Moon	9.2 a.m.
	26—Last Quarter	1.33 p.m.
	6—Perigee	1.0 p.m.
	22—Apogee	8.0 a.m.
September	2—New Moon	2.15 p.m.
	9—First Quarter	5.32 a.m.
	17—Full Moon	12.41 a.m.
	25—Last Quarter	3.47 a.m.
	3—Perigee	4.0 p.m.
	18—Apogee	6.0 p.m.
October	1—New Moon	10.41 p.m.
	8—First Quarter	4.18 p.m.
	16—Full Moon	6.15 p.m.
	24—Last Quarter	4.4 p.m.
	31—New Moon	8.3 a.m.
	2—Perigee	2.0 a.m.
	15—Apogee	8.0 p.m.
	30—Perigee	2.0 p.m.
November	7—First Quarter	7.8 a.m.
	15—Full Moon	12.23 p.m.
	23—Last Quarter	2.36 a.m.
	29—New Moon	6.42 p.m.
	12—Apogee	2.0 a.m.
	27—Perigee	10.0 p.m.
December	7—First Quarter	2.1 a.m.
	15—Full Moon	5.38 a.m.
	22—Last Quarter	11.45 a.m.
	29—New Moon	6.56 a.m.
	9—Apogee	6.0 p.m.
	25—Perigee	4.0 p.m.

N.B.—Apogee—the point in the Moon's orbit farthest from the earth. Perigee—the point in the Moon's orbit nearest the earth.

There will be a transit of Mercury across the disc of the Sun on the 12th November, visible in the eastern portion of Australia between 7 and 11 a.m.

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THE

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TERRITORY OF NEW GUINEA.

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Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
Volume 6, Number 1.

Copies of all numbers of the *Gazette*, except Volume 1, Number 1, are available at one shilling each.

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All articles submitted for publication in the *Gazette* should be typed with double spacing. Carbon copies should not be sent. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

References to articles and books should be carefully checked. In a reference the following information should be given: Initials of author, surname of author, full title of article, name of journal, volume, full date, number of the first page of article. If a reference is made to an abstract of a paper, the name of the original journal, together with that of the journal in which the abstract has appeared, should be given with full date in each instance.

Authors who are not accustomed to preparing drawings or photographic prints for reproduction are invited to seek the advice of the Editor.

COMMUNICATIONS.

All communications should be addressed to the Editor, *The New Guinea Agricultural Gazette,* Department of Agriculture, Rabaul.

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Editor of the *New Guinea Agricultural Gazette*	R. C. Hutchinson, B.Sc.

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THE

New Guinea Agricultural Gazette.

Vol. 6. AUGUST, 1940. No. 2.

EDITORIAL NOTES.

Recently approval was given for the appointment of the Agricultural Chemist as Editor of the *New Guinea Agricultural Gazette.* In future, it is proposed to issue four *Gazettes* a year in the following months—February, May, August and November. Those desirous of submitting material for publication should arrange that it reaches the Editor ten weeks before the first day of the month of publication of the *Gazette* for which it is intended.

The main features of this issue are the annual reports of the senior officers of the Agricultural Department and two articles by the Assistant Entomologist on coco-nut leaf pests.

Recently, *Promecotheca papuana,* Csiki, was discovered on a plantation on New Ireland. Fortunately, only a few palms were affected. These were cut down and burnt, and a careful lookout kept for other affected palms. This is the first record of the disease occurring in New Ireland.

Many inquiries have been received of late as to the prospects of rubber production in the Territory. As a result, the Economic Botanist is preparing a detailed report which, it is hoped, will be ready for publication in the next *Gazette.*

Cacao is another crop which is receiving added attention of late. Owing to war conditions restricting the importation of cacao from other countries, the New Guinea product is now bringing a much better price in Australia. This crop does well in many parts of the Territory and commences to bring in returns after about three years. Seeds of high quality may be obtained from the Keravat Demonstration Plantation at a reasonable price.

ANNUAL REPORTS OF THE DEPARTMENT OF AGRICULTURE FOR THE YEAR ENDING 30TH JUNE, 1939.

DIRECTOR'S REPORT.

The Director, apart from administrative duties, paid many visits to plantations in the Gazelle Peninsula and directed operations at the Demonstration Plantation, Keravat. He also made an extensive tour of inspection of plantations on New Ireland from Kavieng to Namatanai, with Mr. G. W. Stanley, Inspector and Instructor, during which land for the head-quarters of an inspector and instructor was selected at Bo, Namatanai district. The locality chosen is on a branch road of the East Coast-road, New Ireland, so that, with a vehicle, the inspector can be in frequent touch with most planters and natives on New Ireland, the largest coco-nut growing area in the Territory. The Director addressed a meeting of planters at Kavieng on copra production which was well attended.

A visit was paid to Aiyura, 6,000 feet elevation, for the purpose of inspecting cinchona, coffee and other crops introduced to that highland district. Too much cannot be said for the energy and enterprise shown by the Officer-in-charge of that station, and the commanding influence he and his wife have over natives from the so-called uncontrolled area.

Later, the Director visited Wau, 3,000 feet, where he inspected several farms which the owners were struggling to establish by the production of food crops for the European settlement. The coffee, *Arabica* (Blue Mountain Jamaica), introduced by the Department eight years ago is still thriving and producing heavy crops which shows the district to be well suited for this valuable crop.

At Lae the holdings of the settlers in that district were inspected and instructions given to the owners individually, in addition to a public address on cacao and rubber planting. The meeting was attended by practically all the residents of Lae and apparently was greatly appreciated.

Mr. J. L. Froggatt, Entomologist, was largely engaged during the year on the breeding and distribution of parasites, particularly *Pleurotropis parvulus*, of the coco-nut leaf mining pest *Promecotheca papuana*, full particulars of which are given in a separate report.

Mr. R. E. P. Dwyer, Economic Botanist, made an extensive patrol of the north-western islands to investigate the decreased production of coco-nuts in that portion of the Territory.

An Agricultural Chemist was appointed to the department and when he commences duty, reliable advice on chemical fertilizers can be supplied to the planters.

Mr. B. A. O'Connor, stationed at the Entomological Field Laboratory at Manus, was engaged on investigations for the control of the coco-nut tree-hopper, *Sexava*, and proved that dusting with arsenical powders could effectively control the pest. He was also employed in breeding and liberating *Pleurotropis parvulus*, on Lindenhafen and other areas infested with *Promecotheca papuana*.

Mr. C. C. Marr, Inspector and Instructor, has been stationed at Vunakanau in charge of native agriculture and to advise planters in the Kokopo district. The natives in this district being between two centres like Rabaul and Kokopo, are probably the most sophisticated in the Territory, but Mr. Marr's experience of native mentality has given him considerable influence over them.

Mr. Brechin, Officer-in-charge of the Agricultural Station at Aiyura, on the Upper Ramu, Mainland of New Guinea, is doing good work amongst totally uncivilized natives. Soy beans and other new foods have been introduced to them and the improved dietary should have a beneficial effect on their stamina. Natives come from long distances within the uncontrolled area and make friendly visits to the station, getting instruction in agriculture and taking seeds and plants back to their village gardens. Cinchona of four types, including high quality *C. ledgeriana*, are thriving at the station and there is good reason to believe that it may yet be the foundation of a new industry. Arabian coffee, tea, pyrethrum and many fruits are established on the station.

Pests and Diseases.

The two most serious coco-nut pests in the Territory have received careful study by the entomological staff and very satisfactory progress has been made. The parasite, *Pleurotropis parvulus*, has, we have good reason to believe, become established in the Territory and has brought the coco-nut leaf-miner beetle, *Promecotheca papuana*, under control. The parasite, *Leefmansia bicolor*, has not proved as successful as hoped on Manus, but demonstrations prove that the pest can be kept under control by dusting with arsenical powder.

Attempts are being made to introduce *Tetrastichodes*, parasites on the leaf hispa, *Brontispa froggatti.*

The *Bufo marinus*, introduced from French Guiana, via Trinidad, Hawaii and Queensland, has become thoroughly established and reports indicate that it is successful in controlling various insect pests including *Hippotion celerio*, a serious pest of sweet potatoes. Many other insect pests and diseases have been investigated by the entomological staff and the Economic Botanist.

Copra.

The year 1938-1939 has been an unfortunate one for the coco-nut planter on account of the depressed state of the copra market. The drop in prices started in February, 1938, and there was a slow and steady decline so that only those planters producing under the most favorable circumstances were able to have a margin of profit. Nevertheless, there is no reason for undue despondency, as copra produces the most valuable of all vegetable oils but, like the wheat farmer, the coco-nut planter must endeavour to increase his yields per acre at the lowest possible costs if he is to obtain reasonable profits. The correct use of leguminous cover crops, tall as well as creeper, and the right application of suitable fertilizers, have been repeatedly used to increase yields unless the plantation is too far gone.

Desiccated Coco-nut.

The production of this commodity has been maintained and sells at remunerative prices in Australia. There is no possibility of expanding this branch of the industry as Australian demands can be met with the present production and, as an export trade, there is not much likelihood of being able to compete with Ceylon.

Fresh Coco-nuts for the Fruit Trade.

This small industry apparently has collapsed as it suffered from infrequent shipping facilities and could hardly be expected to be able to compete with nearer coco-nut growing countries like Fiji.

Coir Fibre.

There is one mill established in the Territory and the samples of fibre examined by the Department were quite equal, if not superior, to the Ceylon article.

Coffee (Robusta type).

In one instance, this industry suffered from bad plantation management, but another large plantation has been put under a capable manager and reports show that there has been a great improvement in its maintenance and yield. Arabian coffee at Wau, 3,500 feet above sea level, still continues to yield heavily and the owner has extended his planted area. The small area of this variety (Blue Mountain Jamaica) at Aiyura is very healthy and has commenced bearing.

Cocoa.

The area planted with this crop continues to increase but, despite recommendations of the Department of Agriculture, few planters take the trouble to plant selected seed, although seed of high quality trees at Keravat are available at reasonable rates.

Tea.

The plants introduced to the Agricultural Station, Aiyura, suffered a serious set-back and a number were destroyed by fire, but those remaining are now coming on well.

Derris.

Little advance has been made in the cultivation of this valuable crop. It is a relatively quick-growing crop compared with coco-nuts but many planters in this Territory, accustomed as they have been to the latter, find difficulty in entering upon a new crop that requires cultivation in its early stages.

Rubber.

On account of the higher prices now obtained from this product and the depressed state of the copra market, several planters are talking of entering upon its cultivation. Numbers of planters have purchased seed of *Hevea*, but no new plantations have yet been started.

Cinchona.

Four species and hybrids, including *C. ledgeriana*, of this plant have been established at the mountain agricultural station, Aiyura. The growth of these plants has been very satisfactory and, considering their age, seems to indicate that soil and climate are even suitable for the more delicate and valuable *C. ledgeriana*.

Peanuts.

This plant has now entered into native agriculture, being always found in every village garden, and is much appreciated in native diet.

Vegetables.

An increasing quantity of European vegetables is now being grown by natives in the neighbourhood of settlements for which there is a good demand from Europeans and Chinese. Seeds were introduced by the Agricultural Department in the first place, but the product is far inferior to cold storage vegetables imported from Australia. Inspectors and instructors of the Department are doing their best to raise the standard of these crops by instruction to natives.

Assistance to Planters.

Every possible assistance continues to be rendered to planters. Parasites for the control of *Promecotheca*, a serious pest of coco-nuts, has been bred in the Department's entomological laboratory and distributed to planters in all those districts attacked by this pest.

Advice has been given on many subjects to planters by the Director and other members of the staff, and several planters have expressed their appreciation of the assistance thus rendered.

Selected seeds of high-yielding cacao, coco-nut and other plants have been distributed in large quantities at reasonable prices from the Demonstration Plantation. Small numbers of plants of economic and ornamental types have been distributed gratis for experimental purposes from the Botanic Gardens.

Samples of soil have been continued to be sent to the Waite Institute in Australia for analyses. This is very kindly done as a special favour to the Department, as we have no claim on the services of this institution.

Native Agriculture.

This branch of the Department's activities has received every attention throughout the year, as it is an important part of the duties of inspectors and instructors.

Three inspectors have been stationed in centres of relatively large native population and have been able to be in frequent contact with the natives to advise and instruct them in improved methods of cultivation, and introduce new food plants to them. In certain cases, even tools have been issued to them on loan.

Practically all native coco-nut groves throughout the Territory have been inspected, and in many cases there has been a marked improvement in their maintenance by the introduction of cover plants and correct cultural practice.

Owing to the slump in market prices, natives have shown a distinct disinclination to turn their nuts into copra, which, after all, clearly shows that copra production is not essential for their maintenance. Their gardens are sufficient to provide them with all their food requirements and copra is only used to provide them with the luxuries of life. Until these luxuries become essentials, thus raising the standard of living, we can hardly hope for any permanency in advanced native agriculture.

ENTOMOLOGIST'S REPORT.

Froggatt - 4

From January, 1939, to June, 1939, the Entomologist was appointed Acting Director during the absence of the Director on sick leave.

Owing to the very close attention required in the *Promecotheca* parasite breeding and the extra duties entailed as Acting Director, the Entomologist has not been able to visit other portions of the Territory for the greater part of the year.

The following areas, however, were visited:—

Manus and the Western Islands—from 19th July to 30th July, 1938.
Buka Passage sector—from 13th to 24th August, 1938.
South Coast, New Britain—from 5th to 13th September, 1938.
Pondo Plantation, New Britain—23rd to 29th September, 1938, and 12th to 16th May, 1939.
Rabaul-Kokopo area visited on single-day trips in connexion with observations on various pests.

Parasites of *Promecotheca papuana*, Csiki: On 6th October, 1938, a colony of *Pleurotropis parvulus* larval and pupal parasites of *P. papuana* was landed successfully by air liner from Fiji through the assistance and co-operation of W. R. Carpenter & Co. Ltd.

Two previous unsuccessful attempts had been made to introduce this parasite, one from New Hebrides and one from Fiji.

Breeding of *P. parvulus* to build up stocks of the parasite for liberation was immediately commenced; the life-history of this species, together with that of the two indigenous larval parasites *Eurytoma promecothecae*, Ferr. and *Closterocerus splendens*, Kow. was studied in detail, and in each case the life was found to be approximately half that of the host. Instruction in breeding these parasites was given to several planters who desired to build up the parasite population on their own plantations.

Breeding material was drawn mainly from one plantation in the Kokopo district, where a mild infestation of *P. papuana* was present over a large area of young coco-nuts; a few other localized centres of mild infestation in the Rabaul-Kokopo area also contributed a quota. Early in December, 1938, the supply of material available showed a marked decrease and declined steadily until the end of January, 1939, when it had practically ceased. This was due to the combined effects of the three species of parasites referred to.

Liberation of *P. parvulus* was commenced early in November, 1938, in the Rabaul-Kokopo area wherever any evidence of infestation by *P. papuana* was observed. Colonies were also despatched from Rabaul to the Talasea sub-district, New Britain, and to Manus District.

Owing to the limited supply of breeding material from the inception of the work in Rabaul, and the continued prevalence of the pest in the Gasmata sub-district, New Britain, the Assistant Entomologist was, in November, transferred from Manus district to Gasmata sub-district, with head-quarters at Lindenhafen, to carry out breeding and distribution of *P. parvulus* and to make a general study of the pest and any indigenous parasites in the latter area.

From this area liberations of *P. parvulus* were commenced early in December, and were recovered from parasitized larvae collected in the field early in February. The single phase of *P. papuana* has persisted in Lindenhafen, and it has been found that this condition has, to date, militated against a mass carry-over of the parasite from one host generation to the next. This matter is receiving further study.

Colonies were also supplied from the Field Laboratory, Lindenhafen, to other centres in the Gasmata sub-district, for Linga-Linga, Talasea and for Manus.

A ready control of the adult beetles has been obtained by spraying with Arsenate of Lead and Nicotine.

Rhyncophorus papuanus, Kirsch (Black Palm Weevil), has given a considerable amount of trouble in the Gazelle Peninsula, New Britain. Tests are being started with a proprietary preparation from Ceylon.

Two consignments of copra from a plantation in the Manus group were so heavily infested with the larvae of *Ephestia cautella* that fumigation had to be resorted to in order to prevent increased population of the moths in the sheds. The bags were stacked in the Departmental fumigator in rows with dunnage between layers and treated with hydrocyanic acid gas for 48 hours, the fumigant being generated from "Cyanogas" calcium cyanide used at the rate of 3 lb. per 1,000 cubic feet.

The Braconid, *Bracon bebetor*, Say, was later found breeding in considerable numbers in the *Ephestica* larvae.

The Giant Toad, *Bufo marinus*, is being distributed to various parts of the Territory to endeavour to control the pest, *Hippotion celerio*, of sweet potatoes.

At the break of the dry season at Buka Passage, cutworms did considerable damage to various crops for a short period until parasites gained control. *Prodenia litura* on Taro, *Heliothis obsoleta* on Maize were particularly numerous and *Pseudococcus* sp. and *Coccus viridis* on coffee. Spraying with a miscible oil spray has given control of these coccid pests.

The following articles were published during the year in the *New Guinea Agricultural Gazette*:—

XXVII. 277. (1) "Measures for Control of *Sexava* spp."
" 11 (2) "Weevil Pests of Cocoa."
" 544. (3) "Pests of Cocoa in the Territory of New Guinea."
XXVIII 49. (4) "The Coco-nut Leafminer, *Promecotheca papuana*, Csiki, and its parasites in the Territory of New Guinea."
(5) "Fumigation and Fumigants."
" 51. (6) "Insect Pests of Rice."
" 153. (7) "Copra Infestation by *Ephestia cautella* and fumigation for its Control." (With Mr. F. O. Moody as co-author.)

The following insect pests, parasites and predators are recorded for the year, and were either bred or collected in Rabaul and other parts of the Territory:—

COCO-NUTS—
Coccidae—*Dinaspis veitchii*, Green and Laing.
Coccus mangiferae, Green.
Ischnaspis longirostris, Sign.
Pinnaspis pseudoaspidistrae, Green.

Parasites of *Promecotheca papuana*—
Eulophidae, *Eurytoma promecotheca*, Ferr.
Closterocerus splendens, Kow.
Derostenus sp.
(all larval parasites).
Eupelmidae, *Anastatus* sp. (egg parasites).
C. splendens and *Anastatus* sp. are recorded from Manus and New Britain.

Predator of *Promecotheca papuana* adults—
Pentatomidae, Anyotea reciprocus, Wlk. var.
Sexava egg parasites, Lilui Island—
Scelionidae, Prospagus attrellus, Dodd.
Eulophidae, Tetrastichodes sp.

COPRA—
Pyralidae, Ephestia cautella, Wlk.
Bracon hebetor, Say, (Braconidae), larval parasite of *E. cautella.*

COCO-NUT SPATHES—
Curculionidae, Meredolis cocotis, Mshll. (collected Kokopo, New Britain).
Metroxlyn sagu—
Curculionidae, Rhyncophorus kaupi, Schauf. (collected Huon Gulf, Morobe District).

COCOA—
Noctuidae, Erias citrina, Saalm. on foliage.
Eucosmidae, Laspeyresia sp.—larvae boring in shell of pods.
Limacodidae, Scopelode sp., on foliage.
Coccidae, Pseudococcus sp. on pods.
Thysanoptera—Heliothripis haemorrhoidalis, Bouche, *Selenothripis rubrocintus*, Giard, both spp. on the foliage.

ERYTHRINA—
Noctuidae—Othreis fullonica L. on foliage; the adults of this moth caused marked damage to ripening citrus, pawpaws, bananas, &c.
Coccidae—Ferrisia virgata, Ckll.

COFFEE—
Coccidae: Coccus viridis Green.
Mealybug predators—
Coccinellidae, Alesia lineata, Thumb.
Cryptolaemus montrouzeri, Muls.
Scymus sp.

LYGAEIDAE—
Scopiastes sp.—this specimen was always present in numbers on coffee bushes infested with mealybug.

MANGO—
Trypetidae, Dacus frauenfeldi, Schin. in fruit.
Boisteres sp. nr. *compensans*, Silv. (*Braconidae*)—parasite of larvae of *D. frauenfeldi.*
Drosophyllidae, Drosophila punctipennis—sub-sp. *parapunctipennis Duda.* in over-ripe fruit.
Eucosmidae—Argyrploce aprobola, Meyr. on foliage.
Eugenia mallacensis—
Trypetidae, Dacus frauenfeldi, Schin. in fruit.
Drosophyllidae, Drosophila punctipennis—sub-sp. *parapunctipennis Duda* in over-ripe fruit.
Tortricidae, Homona aestivana, Wlk. on foliage.

TOBACCO AND TOMATOES—
Capsidae, Eugytatus tenuis, Tent. on flowers—causing the blossoms to fall.

VARIOUS HOSTS—

Lepidoptera.

Noctuidae, *Serrodes campana,* Mab. and
Oxyodes ochreata, Roth. on rembutan foliage.
Parallelia stuposa F. on Acalypha foliage.
Parallelia palumba, Guen, on citrus, on foliage.
Hyblaea fuera, Cram. on Teak foliage.
Erias fabia, Cram. and *Anonis flava* F., on "Aibika."
Sphingidae, Deilephila placida, Wlk. on *Taberne montana.*
Tortricidae, *Homona mermerodes,* Meyr. on Clerodendron foliage.
Adoxophytes sp. nr. *melichron,* Low on peanut foliage.
Lyonetidae, Opogona taochroa, Mehr. in sugar-cane.
Cosmopterygidae, Pyroderces tripola, Meyr. in seed of pods of *Octomeles sumatrana.*
Heliodinidae, Strathmopoda sp. in ripe fruit of Madagascar plum.
Eucosmidae, Laspeyresia sp. in Carembola fruit.
Gracillaridae, Acrocercops cramerella, Snell, in fruit of *Synometra cauliflota.*
Rhyncota, Halticus sp. on beans.
Platyaspidae, brachyplatys sp. on beans.
Coccidae, Pinnaspis aspidistrae, Sign. on Maidenhair fern.

ECONOMIC BOTANIST'S REPORT.

Advisory work has of necessity taken up a considerable proportion of the available time and the usual biennial furlough lasted until 24th August of the year under review.

Since arriving in this Territory, facilities have been made available so that most of the planted areas in New Guinea have been visited, many properties three or four times. The properties on the western islands and the plantations bordering Astrolabe Bay close to Madang were visited for the first time this year. The plantations not yet covered are on the mainland coast of New Guinea from Madang to Aitape, Dampier or Kar Kar Island, the Portland Islands and part of Gasmata sub-district.

During the year, the following articles were published in the *New Guinea Agricultural Gazette:—*

(1) "Coco-nut Improvement by Seed Selection and Plant Breeding."
(2) "Fall of Mature Palms in New Guinea Plantations."

In the hands of the printer is an article on "Coco-nut Diseases Associated with Soil Conditions in New Guinea."

Apparently, the low to moderate ruling prices and the uncertainty of the future prospects of the copra market are producing one desired effect in further turning the attention of local producers to other plantation crops. The position for the Territory as a whole is, nevertheless, unfortunate, as there is not so much money available for development.

Cacao cultivation has continued to receive increased attention, which has necessitated much preliminary advice and inspection of areas intended for this crop. Undoubtedly, the provisions of the Bounties Act has also had a good deal to do with this development.

Many inquiries have been received as to the possibility of rubber planting in New Guinea. Investigations of the economic prospects of this crop are being made, as these are not clear. No local publication on the subject has yet been prepared, but detailed notes on methods of planting, clearing, &c., have been furnished to interested planters. A similar circular containing particulars of tapping and factory equipment has been supplied to those plantations where ordinary rubber, *Hevea brasiliensis,* and *Ficus elastica* (Assam rubber), was established during the German régime.

The ruling high prices and the success of the industry in Papua, where 1,243 tons, valued at £129,448, was produced last season, have been to some extent responsible for this increased interest. A more important reason, however, is that on three properties *Hevea* rubber has been established and has flourished for many years without attention, and is now being successfully and profitably tapped. The fact that heavy restrictions have made the high prices possible, is the threatening circumstance.

In practically every instance, it is the economic prospects of the various crops which require elucidating before definite recommendations can be made. The experience of the intending planter and the type of labour available has to be taken into account. Nowhere is this more apparent than on the few lowland coffee plantations here, where the only hope of bringing them to the dividend-paying stage depends on experienced management and supervision. It is for reasons of this nature, that cacao rather than coffee planting seems to be preferable for New Guinea conditions.

It is now known that high-quality *Arabica* coffee, free from coffee rust and berry borers, can be grown at high levels here, but transport facilities and the factors already mentioned will determine future developments. The Kent's Hybrid *Arabica* coffee introduced from India was established on a small scale in an isolated area on the Bainings, through the courtesy of the Catholic Mission. Seed of this high-grade coffee was harvested and sent to the high level station at Aiyura.

It is interesting to note that, as there is no coffee rust (*Hemileia vastatrix*) present here, there are four widely separated places where small areas of *Arabica* coffee are flourishing almost at sea level. The best example of this is at Mandres Plantation, where a few acres of such coffee have been grown and utilized for many years. High-grade coffee is worthy of much greater trial at high levels.

Some planters are now growing their own cover crops and in three cases seed was sold on a commercial basis, which is a desirable development.

Property Inspections.

Under an arrangement made by the Custodian of Expropriated Property with the Director of Agriculture, inspections and investigations of a number of old declining properties were made.

The main aspects of maintenance of plantation properties may be said to comprise—

(*a*) Control of pests and diseases.

(*b*) Conservation of the planted areas by cultural methods so that diminution in production is controlled.

Reference to an article entitled "A Survey of the Coco-nut Industry in the Mandated Territory of New Guinea" (see *New Guinea Agricultural Gazette,* Vol. 2, No. 2, October, 1936) and, also, various Departmental reports, outline the problems offered by the obvious decline in output of a considerable number of the older properties in this Territory. These properties very largely comprise the plantations taken over by the Commonwealth Government upon the expropriation of German colonists in 1920-21. Many of these properties are now approximately 50 years planted whilst the youngest of them is nineteen years under coco-nuts. It is obvious that properties giving a low yield of copra per acre show a high cost of production, which is particularly felt when the prices of copra are low.

Reports on the inspections made were submitted to the Department from time to time, and these reports, containing the conclusions arrived at, were passed on to the Custodian. It was found that usually a combination of circumstances, such as age of the palms, linked with soil exhaustion, lack of seed selection and care in the original plantings, and poor cultural methods, was largely responsible for the present condition of the declining properties. Some of them were originally planted all or in part on unsuitable soils, and little could be done about them.

It was also established that the solution of the difficulties is no easy matter. This is largely because soil conditions and the remedial measures which would apply to the soils of the coral atolls of the Western Islands, for instance, have little relationship to those found where plantations are situated on estuarine deposits on the mainland. The soil conditions of both these places are quite different from those of the volcanic pumiceous soils of the Gazelle Peninsula.

In practically every instance, it was possible to make recommendations for improving the planted areas though where the soil profiles are very unfavorable, very little improvement can be expected.

Increased use of cover crops, such as *Centrosema pubescens, Calopogonium mucunoides* and *Pueraria javanica,* such as has been long advocated by this Department, was indicated in most places.

Plant Improvement.

In view of the high variability of the population of palms in plantations, the need for a more scientific system of selection has long been apparent, and is being urged and practised by this Department. Similar variations in yield, quality and other characteristics and the certainty of isolating and breeding superior types, is the aim underlying the plant breeding and selection work on this and various other crops, carried out at Keravat Demonstration Plantation.

Regional strains of coco-nuts, the most noteworthy being the Markham Valley strain, have been isolated and are being grown at Keravat, where they are being used in the selection and breeding programme mentioned in the last annual report. There, it was also pointed out that 33 dwarf or King coco-nut palms were crossed with five selected Markham types of palms as pollen parents. The resultant crossed nuts have now been planted out in an isolated area, the crossed nuts from each mother palm being kept separate.

The Niu Luka, Malayan Dwarf cross palms, introduced from Fiji last season, are planted in the near vicinity and will provide an interesting comparison, It was also pointed out that, assisted by the Superintendent, the best palms only were selected in both the Markham and Dwarf varieties. The Superintendent is now engaged in taking detailed records of the individual palm selections and, until this is complete, it is not posible to do any more crossing. As soon as possible, however, it is intended to artificially cross the best yielding palms within the Markham strain, so as to fix the most desirable types.

Further crossing will then be done between the selected ordinary tall coco-nuts derived from various sources in New Guinea, and the most promising selections of the varieties mentioned.

The coffee cross-breds mentioned as being successfully raised last year have been planted out for observation and selection purposes.

As mentioned in previous reports, a number of selected rubber trees growing in the Botanic Gardens were test-tapped during the season 1937-38, and all of the inferior yielding trees were cut out to allow of cross-pollination between superior yielding types only. Seed of the higher yielding remaining trees was distributed to some interested planters here, and also to the Director of Agriculture, Fiji.

Extensive seed nurseries were also laid down at Keravat with rubber seed derived from the same selected trees. The various selections were kept separate, and are now ready for planting out in plots for comparative testing.

Duplicate nurseries were made with most of the best rubber selections at Rabaul, where an area has been lined and holed in the Economic Section of the Gardens to establish a bud-wood nursery for vegetative propagation purposes.

Plant Introduction and Exchange.

During a visit to Canberra, Australian Capital Territory, arrangements were made with Dr. McTaggart, Chief Plant Introduction Officer of the Council for Scientific and Industrial Research, to take advantage of the extensive and Commonwealth-wide campaign of plant introduction. The Department is greatly interested in possible green manure and cover crops, as well as low-growing, temporary shade and over 60 introductions of these types of plants have already been made through the kind courtesy and co-operation of Dr. McTaggart.

Numerous new plant introductions were made during the year, most economic species being distributed to the experimental stations although representative specimens of various types of fruit trees were retained for the Botanic Gardens.

A fine collection of plants containing several economic species of fruiting plants was obtained from Hong Kong by the Chinese nurseryman when returning from leave.

Herbarium.

Several hundred mounted and carded herbarium specimens were added to the collection during the year. Particular mention should be made of the several specimens of grasses and legumes, collected by Mr. Wood, Inspector and Instructor, stationed in the Sepik District.

As is common in the tropics, it is most difficult to keep the dried specimens free of insect pests. It will probably be necessary to use tin containers inside the tight-fitting, storage cupboards which were obtained last year, In collaboration with Mr. d'Espeissis, a good deal of plant identification work was carried out in the field as opportunity permitted. This work was also greatly aided by the kind assistance of Mr. J. H. L. Waterhouse, who lent some intelligent boys from Nodup School. He also supplied several lists of plants in which the native names from Nodup (Blanche Bay dialect) and other districts had been linked with botanic names of the plant identified for him by Dr. Merrill of the Harvard Arboretum. As far as possible, this work has been checked by cross-references. Other identifications were obtained direct from the Director of the Botanic Gardens, Kew, and from the Queensland National Herbarium.

Mrs. M. S. Clemens, Botanical Collector, sent in a species of grass belonging to the genus *Glyceria*, which is the first record of this genus occurring in New Guinea. She also sent in a species of *Euphorbia complanata*, Warb., which is really a Xerophytic or dryland plant spreading from India to the New Hebrides which is said to represent some botanical evidence of the original land connexions between these countries.

Diseases.

Further investigations and observations on occurrences of physiological disorders (wilts, die-backs, &c.) of coco-nut palms in New Guinea have been continued. The results of these investigations are presented in a *Gazette* ready for publication.

Special attention has been paid to "Maturation Wilts" of young coco-nut palms at the first-bearing stage, which occur from time to time in various parts of this Territory. Reports on soil analyses by the Waite Institute and the comments of their chemist, Mr. J. S. Hosking, and plant pathologist, Mr. D. B. Adam, on the nutrient status and water-relationships of the soils associated with the occurrence of such wilts on plantations at Kokopo and Namatanai have been most helpful. They have indicated the close resemblance between these occurrences, and the "Bronze Wilts" described from Trinidad, although the effects are less severe and other inter-locking, limiting factors seem to be present.

Some pathological derangements of mature palms ("Mature palm wilt"), particularly from those plantations situated on the deltaic and estuarine deposits of the Huon Gulf and Astrolabe Bay areas of the New Guinea Mainland, have been investigated in the field and described together with contributory causes.

Soil profiles and root distributions of coconut palms in such soils and, also, their natural adaptations to changing conditions, have been studied. Although many fungi such as *Thielaviopsis paradoxa*, *Botryodiplodia* spp., *Fusarium* spp., &c., have been found associated with these derangements of coco-nut palms, in every case, the soil conditions were at fault. It was found that in those areas where heavy soils liable to waterlogging exist, there is decided necessity for root adjustment in the change-over period from the wet to the dry season, which under normal conditions often has a marked physiological effect on the palms. Seasonal breeding, nut-fall, leaf-droop, frond-fall and often loss of palms, may occur, where the surface-layers are liable to waterlogging with the formation of a super-imposed water-table in the wet season, and to drying out and cracking in the dry season. This effect is greatly exaggerated either where hard pans exist or conversely, where rubble and sand layers exist.

Some occurrences of the falling of healthy, mature coco-nut palms associated with particular physical conditions of soil and sub-soil have also been investigated in the field and the findings published (see *New Guinea Agricultural Gazette*, Vol. 5, No. 1).

In parts of the Witu Island Group coco-nut palms were found to flourish and produce good crops despite the fact that their roots could not penetrate more than 18 inches at the most, owing to the presence of hardened rock-layers as the newly-derived soil was of volcanic origin and very rich and friable. In the deep pumice soils of Rabaul, a few roots of young palms were seen to have reached a depth of at least 30 feet.

It has been clearly determined that from a practical standpoint, the study of soil profiles, as to depth, presence of hard-pans, &c., has yielded much information concerning the suitability of particular areas for coco-nut cultivation. It has also proved of great value in assessing the actual potential value of plantations even where chemical data cannot be obtained.

The importance of proper cultural conditions in relation to the control of most coco-nut diseases, but particularly those of physiological origin, is most apparent. The necessity for detailed chemical and botanical research on the nutrition of coco-nut palms in relation to the soil conditions found here has also been clearly indicated.

The Director of Agriculture and other departmental officers investigated and macroscopically diagnosed true "bud-rot" on one plantation here. Microscopic examination of specimens of diseased tissue made by the Imperial Mycological Institute revealed the presence of fungus mycelium which they considered to be *Phytopthora* from measurements taken. Detailed microscopic examination of fresh specimens was later made in the laboratory at Rabaul. It was found definitely that the bud-rotting fungus *Phytopthora palmivora* was associated with the diseases. The best microscopic slides were obtained from a naturally-isolated, almost pure culture of the organism in the central tissue of the lower trunk (a most unusual site for this fungus to occur). The mature spores (oo-spores) and resting spores were unmistakable under the microscope as they showed the varying forms and the pronounced beaks characterising the spores of this fungus.

The same fungus was found associated with a case of "spear die-back" of oil palms at Keravat some time ago, but only a few palms were lost and the condition cleared up.

The bud-rot developed under flat and foothill conditions in a region of heavy rainfall in an abnormal climatic season, and even then only in areas where the palms were growing on heavy soil, liable to water-logging. A visit was made to investigate the possibility of this disease spreading to other properties. The indications are very strong that the disease would only prove serious under comparable conditions to those indicated, as the fungus can only develop in a very moist atmosphere.

It is certain that the fungus *Phytopthora palmivora* is widely spread in the Territory of New Guinea and, apart from the coco-nut palm, there are plenty of other host plants available (e.g., cacao, betel nut, *Areca catchu*, oil palm, pawpaws, *Hevea* rubber, &c.), which this fungus does attack. It would appear, therefore, that it is only under certain special circumstances that this fungus causes serious loss of coco-nut palms and probably only when a virulent strain of the fungus is present. Strong measures are being taken to control the disease and, although there has been a loss of palms spreading over twelve months, the disease has been confined to one property.

On one coffee plantation here, improved plant sanitation, as recommended, has reduced the incidence of thread-blight (*Corticium kolerga*), die-back (*Diplodia* spp.) and root rot to a minimum, although they were formerly causing much damage.

On old properties here, where rubber was interplanted with cacao and then neglected, it was seen that root rotting fungi, *Fomes* spp., *Ustilinia* spp., *Rigidoporus microporus*, &c., have spread from the cacao to the rubber which would indicate one danger from interplanting these crops.

Eelworms or parasitic nematodes (round worms) of microscopic size are common causes of plant diseases in New Guinea.

Heterodera radicicola.—These nodular eelworms were found causing serious damage to the roots of crop and garden plants last season. They have a very wide range of hosts and are difficult to control. They were found here on tobacco, tomatoes, rice, pawpaws, *Patchouli pogostemmon,* bush-shrubs, and caused very serious damage on the garden balsams, *Impariens balsamina,* and on gerberas.

From specimens of diseased yams and slides sent, Dr. Goodey, of the Institute of Agricultural Parasitology, England, has identified *Anguillulina pratensis,* as associated with the sapronphytic eelworms, *Cephalobus striatus, Aphelenchoides parietinus* and *Rhabditis* spp. He recommended washing the yams for a certain period and painting their lesions with a solution of iodine in potassium iodide at a dilution of 1 in 5,000 as treatment.

The saprophytic eelworm *Cephalobus rigidus* has been isolated and identified from coco-nut fronds but, so far, no parasitic species such as occurs in the West Indies have been observed damaging the palms.

The fungus *Rhizoctonia* spp. was found causing serious damage on the tennis court lawns of the Botanic Gardens, Rabaul. The severe damage was probably assisted by pumice compaction and alteration of the soil reaction. Prompt action has been taken to remedy this by removing several inches of the surface soil and renewing with fresh soil which meant complete replacement of the lawns.

Several diseased plants were sent to the Department of Agriculture for identification. It was seen that leaf-spots due to *Cercospora* spp. were common cause of trouble with vegetable plants such as beans and frog-eye spots, *Xercospora nicotianae,* were so severe as to lessen the value of leaf tobacco for native use.

Specimens of *Diplodia* and *Botryodiplodia* fungi from rubber, cacao and coffee, were sent by request to the Agricultural Experiment Station, Florida, for comparative studies.

Numerous types of grass rusts were supplied to the University of Sydney to assist in scientific studies connected with cereal rusts.

Specimens of probable new kinds of loose smuts and flagsmut on various grasses and sedges were located and sent to Professor Zundel of the State College, Pennsylvania, for his studies on the " Smuts of the World ".

THE COCO-NUT LEAF-MINER, *PROMECOTHECA PAPUANA*, CSIKI., AND ITS PARASITES.

(*B. A. O'Connor, B.A., B.Sc.Agr., Department of Agriculture.*)

In various parts of the Territory of New Guinea, chiefly on the island of New Britain, the Coco-nut Leaf-Miner has caused extensive damage to plantations and native groves. The two most serious outbreaks in recent years were those in the Rabaul district following the volcanic eruption of May, 1937, and at Lindenhafen in the Gasmata district, on the south coast of New Britain, in 1936. In the main, the pest appears to be controlled by native parasites, and the mortality among these during the eruption is believed to have been responsible for the Rabaul outbreak. The reasons for the severity of the attack at Lindenhafen are obscure, but a study of the conditions there has brought to light some interesting data.

In a severe infestation, the extent of the damage to the palms can be very great. The leaflets are completely destroyed, turning a greyish-brown colour, and giving the palms the appearance of having been scorched by fire, while in some cases the central shoot may be extensively damaged, leading to the death of the palm. Recovery is slow, and there may be a cessation of nut-production for as long as two years, the immature nuts falling to the ground as a result of the debility of the palm. Where attack is less severe, drying and curling of the tips of the fronds is noticeable, together with the elongated, brown patches due to mining of the larvae within the leaflets.

Data relating to the life history and habits of the beetles and its parasites have been compiled during the course of investigations at Manus in 1938, and at Lindenhafen, New Britain, in 1938-39. The method of rearing and observation was as follows:— (South, nr. Gasmata)

One or more pairs of newly-emerged adults were placed in wire sleeves attached to a growing palm in such a way as to contain several leaflets. The wire sleeves were cylindrical, about 18 inches long and 4 inches in diameter, and at each end were continued into cloth cylinders about 6 inches long, which served to close the wire cylinder, and render it beetle-proof. Palms of from six months to a few years old were used, as their foliage is more easily accessible. When the palm used was only a few feet high, a stake was placed in the ground a few feet away, and one end of the cylinder attached to a piece of twine coming from the end of the stake. Thus the weight of the cylinder was supported largely by the stake. When older palms were employed, a piece of tie-wire was passed along one side of the cylinder, and was attached to the mid-rib of the frond. Cotton-wool wrappings were always used to ensure that the cloth fitted tightly over the leaflets, as otherwise the beetles were able to escape. When food became exhausted, or when several egg-masses had been laid on the leaflets, the beetles were moved to fresh leaflets. Egg-masses were marked, and the development of the eggs and larvae followed up. Life histories of larvae were worked out also in the laboratory, where larvae could be carried through in leaflets kept in water, being put into mines in fresh leaflets whenever necessary.

Bionomics of *P. papuana.*

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The Eggs.—The eggs, which are dorso-ventrally flattened, oval objects, are laid almost invariably on the underside of the leaflet, very occasionally on the upper surface, and are covered with excrement by the female beetle. The mound thus formed is oval, about ⅛ inch long, with a rough, biscuit-coloured surface. Egg-laying takes place in the evening, during the last hour before sundown, and the number of eggs per egg-mass is from one to six, averaging about three. In Manus, the usual number is three, and five is an extremely uncommon total, while at Lindenhafen four is the usual number, five is not uncommon, and six is very rarely met with. Before laying the eggs, the female beetle chews a furrow in the leaf surface in the spot where the eggs are to be laid, so that the young larva, on emerging, is able to enter the interior of the leaflet. The larva is unable to penetrate an undamaged leaf surface, as its head is very strongly flattened dorso-ventrally, the pincer-like mandibles working in a horizontal plane.

The Larva.—The larva is a cream-coloured grub, with strongly chitinized head and mouth-parts, golden-brown in colour. On hatching from the egg, it immediately works its way inside the leaflet, using the furrow made by the female beetle, and normally feeds straight ahead, cutting a wide track through the green matter of the leaflet, which it tears away by the pincer-like action of the jaws. Only the epidermis of the leaflet is left above and underneath the mine, and before this begins to dry, the larvae can clearly be seen feeding when a mine is held up to the light. Regular swathes of excrement are left behind in the mine as the larva advances. The average number of larvae per mine is about three, but during severe infestations twenty or thirty egg-masses may be laid on one leaflet, and several mines made by young larvae may run into one another. As many as thirteen larvae have been seen by the writer feeding abreast in a single mine. In such cases, of course, usually only a few larvae reach maturity, the majority perishing of starvation.

There are three larval instars, and at the end of each of the first two, a larval skin is cast. The fully-fed first-instar larva retires backwards down the mine, and a quiescent period of two or three days follows, during which the old larval skin is cast. Feeding then continues until the end of the second instar, when the process is repeated. On the completion of the third instar, no skin is cast, but the larva ceases feeding, and spends about three days as a resting prepupa, the latter differing only slightly in external appearance from the fully-fed larva.

The places at which feeding for each instar has ceased can often be seen in an external view of the mine. At the end of each instar, the green tissue of the leaf which the larva has been attacking dries hard, leaving a visible mark after the larva has again begun to feed, which it does by first biting through the dried tissue. The position of the larva in the mine can best be called "lying on its back", the dorsal portion of the body always being towards the ground. This position is maintained by the pupa, so that normally the newly-hatched adult beetle is placed with its mouth-parts in proximity to the upper surface of the mine, and hence it bites its way out through this surface. When a larva is being examined outside the mine, the dorsal surface can always be distinguished from the ventral, as the larva bows itself backwards, the inner portion of the curve being formed by the dorsal surface.

Prepupa and Pupa.—When the resting stage of the prepupa is completed, the old skin splits along the dorsal portion of the thorax, and the pupa forces its way out. A series of convulsive movements by the pupa sloughs off the old skin until it comes to rest at the dorsal end of the pupa, forming a small attached lump, the most noticeable portion being the chitinized head and mouth parts of the old larval skin. Later on, this lump falls off the pupa, leaving it quite free.

The colour of the pupa, when it is first formed, is creamy-white, but it quickly darkens until it reaches a golden-brown tint. Later, eyes, mouth-parts and elytra become black. It is armed with rows of spines on the dorsal surface of the abdominal segments, and these enable it to move freely within the mine by gripping the epidermis of the leaf as it progresses by alternately doubling and straightening itself.

Adult.—The newly-emerged adult is pale yellow in colour, with dark patches on the distal portion of the elytra. The colour gradually deepens, until finally the general colouration is golden-brown, with the prothorax and distal third of the elytra a deep bluish-black. A colour variation occurs in Manus, the beetles in that locality having much paler colouration and markings.

After emergence from the pupa, the adult remains for about two days in the mine before biting its way out. It lies on its back in the mine, with its feet grasping the cast pupal skin. When emerging from the mine, it bites a semi-circle in the epidermis, almost invariably in the upper surface of the leaflet, and forces its way out.

The beetle feeds mainly on the distal third of the leaflets, preferring the older fronds to the younger. Almost all the feeding takes place underneath the leaflets, 466 the green tissue being eaten in fine lines running parallel with the mid-rib. The beetle rests on the leaflets with the long axis of the body parallel to the mid-rib, and turns its head sideways for each bite, so that the mandibles can grasp a portion of the green tissue of the leaf from between the fibres. The damage caused by adult feeding is much more extensive than that due to the larvae. The distal portions of the leaflets become dry and curled, and, where infestation is severe, the whole palm has a brown, scorched appearance.

Copulation occurs frequently, and copulating pairs show a tendency to be gregarious. Pairs of beetles which have been kept under observation have been seen to copulate almost daily over a period of two to three months. Seven to ten days after the first copulation, the females begin egg-laying, and continue for some months. They do not lay more than one egg-mass per day, the usual rate being about two egg-masses in three days for the first month or two, after which it is lower.

Adult beetles can live as long as five months, and probably more. Of those kept in captivity, none was kept until it died of natural causes. They either escaped, or were still living when observation had to be discontinued. One female was kept at Lindenhafen for 160 days and a male and female for 140 days. Copulation was noticed with beetles 135 days old.

It would appear that the female can lay about 80-100 eggs, that is about 30 egg-masses at Manus, and 25 at Lindenhafen. The pre-oviposition period is commonly about four weeks or a month, 24 days being the shortest period noted. At Manus, life-history observations were interrupted before oviposition was completed, but the average oviposition by four females was 22 egg-masses in 41 days. At Lindenhafen it appeared that there was a break in the continuity of egg-laying. Thus, two females under constant observation laid eggs as follows:—

Emergence of adult from mine.	First oviposition period began.	First oviposition period ended.	Second oviposition period began.	Second oviposition period finished.
	16 Egg-masses		4 Egg-masses.	
A.—10th to 11th February	10th March	6th April	8th May	22nd May.
	28 days	27 days	32 days	14 days
	13 Egg-masses.		11 Egg-masses.	
B.—14th February	14th March	15th April.	27th May	27th June
	28 days	32 days	42 days	31 days

It will be seen that the total period of oviposition for A is 73 days, with a break of 32 days, and for B 105 days, with a break of 42 days.

Figures for the developmental period of eggs, larvae and pupae are given below:—

Eggs.—At Manus, the incubation period varied from 13½ to 16 days, with an average of 15 days. At Lindenhafen, the range was 13 to 15 days, with an average of 14 days.

Larvae and Pupae.—Data are presented in the following table (the figures are in days):—

——	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
First stadium ..	9	8	8	5	5	5½	5	6	6	6	6
Rest	3	2	3	2½	2	3	3	3	3	3	3
Second stadium ..	5	5	5	3	3	2½	3	8	8	8	13
Rest	3	3	3	2½	3	3	2½	2	2	2	3
Third stadium ..	8	10	10	7½	6	6	4	6	7	8	12
To emergence of adult ..	[illegible] 16	[illegible] 15	[illegible] 15	20½ 15	19 15	20 15	17½ 15	25 15	26 15	27 15	32 15
Total, egg to adult	44	43	44	35½	34	35	32½	40	41	42	52

Mines A to G inclusive were under observation on growing palms at Manus. Mines A to C were in mature leaflets, while mines D to G were in leaflets of a palm about six months old. It will be noticed that there is a marked difference in the developmental period of larvae from these two sets of mines. H to K are single larvae from the same mine at Lindenhafen. These were reared in the laboratory on leaflets kept in water. Larva K, it will be noticed, had a very much longer developmental period than larvae H to J. The period of 15 days from the end of the third stadium to emergence of the adult from the mine is very consistent, and is made up normally of a prepupal period of 3 days, pupal 10 days, and resting adult two days.

At Lindenhafen, where in certain localities there was a definite break in the normal overlapping of life-history stages, field observations indicated that the length of a generation was three months. This was the period which elapsed between first appearance of adults in one generation and first appearance in the next. However, the average length of a generation would be longer, calculating from the middle of one oviposition period to the middle of the next. On this basis, the average length of a generation could be estimated as follows:—

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—	Manus.	Lindenhafen.
	Days.	Days.
Incubation period	15	14
Larval period	28	30
To emergence of adult	15	15
Pre-oviposition	45–50	60–70
Total	103–108	119–129

XXIV, 466; Hence there would be between three and four complete generations each year. If we put 28 days as the pre-oviposition period (i.e., the period from emergence of adult to first egg-laying), we have just under three months for the generation.

The break in overlapping of generations at Lindenhafen has been mentioned above, and a similar state of affairs appears to exist in the Rabaul district. Having regard to the long period during which oviposition takes place, complete overlapping would be expected to prevail, as, even after a temporary setback, this condition could be produced in one generation. In the beginning of December, 1938, when the writer first went to Lindenhafen, only eggs and adults were present. Later on, only larvae were to be found, then larvae, pupae and adults, then again adults only, and finally adults and eggs only. This was roughly the position during the eight months during which work was carried out at Lindenhafen, and apparently it had been so for a considerable time previously. The break was not absolutely complete, as a very occasional larva might be found during the adult and egg period, but generally speaking, it is true to say that overlapping covered a period of only a month. In other words, it would be possible to have all stages of larvae in the field at one time, or pupae and adults, or adults and eggs, &c., the least advanced stage commonly found being only one month's development behind the most advanced stages. Hence it seems that the longevity of adults in the field may be much shorter than in wire sleeves, as otherwise adults would have been present in considerable numbers at all times. The activities of predators and fungi in reducing the adult population appeared by no means sufficient to bring about the observed conditions. In the case of the eggs, larvae and pupae, the destruction of eggs by internal parasites and by ants is thought to be the main factor in reducing overlapping. This subject will be mentioned later.

Host-plants of *P. papuana.*—Apart from the coco-nut palm, only two other plants have been noted as hosts of *P. papuana*, namely, the sago palm, *Metroxylon sago*, and the oil palm, *Elaeis guineensis*. On the former, the insect can go through all stages of its life-history, but this is apparently not so on the latter. Eggs are laid on it during severe infestation, but the larvae die after the first day or two of feeding.

Parasites and Predators of *P. papuana.*

Pleurotropis parvulus.—This Eulophid had been introduced from Java to Fiji and the New Hebrides to control other species of *Promecotheca,* and had been outstandingly successful. Hence it was decided that it should be imported into the Territory. In October, 1938, a colony arrived in good condition from Fiji, coming from Sydney by mail-plane, Messrs. W. R. Carpenter & Co. Ltd. having given every assistance with the introduction. The parasites were bred up in Rabaul, and distributed in the Rabaul district, Manus, Talasea, Pondo and other localities. At the end of November, the writer was sent with a colony to Lindenhafen, where *P. papuana* was present in very large numbers at the time. Breeding and distribution of the parasite were carried out in this district (Gasmata) until the end of July, 1939, by which time *P. parvulus* was firmly established at Lindenhafen. Daily collection of *Promecotheca* was carried out, so that a check could be kept on the progress of the parasites in the field. It was found that two weeks after the initial liberations, parasitized larvae and pupae could be found on the site of liberation, and even as much as 200 yards away from this point. A gradual increase was discernible in percentage of parasitism in the field, as is shown by the figures given below. Percentages were based only on mines which contained healthy larvae, pupae or adults of *Promecotheca,* or larvae and pupae containing *P. parvulus,* all those from which *P. papuana* or *P. parvulus* had emerged being excluded. Data are appended—

——	Mines containing Parasitized Individuals.	Total Mines.	Percentage of Mines containing Parasitized Individuals.
			Per cent.
6th to 22nd June, 1939 ..	18	414	4.3
23rd to 30th June, 1939 ..	10	451	2.2
6th to 30th June, 1939 ..	28	865	3.2
1st to 14th July, 1939 ..	33	872	3.8

Accurate counts are not available for the latter half of July, but judging from the results obtained from the inspection of several hundred mines, the percentage of parasitism appeared to have jumped rather sharply to the vicinity of 7 per cent. Mines were very few at this period, the average being probably only one or two per palm. In October, counts of mines sent to Rabaul from Lindenhafen showed a 50 per cent. parasitism of mines.

In the Rabaul district, possibly due to the generally drier and finer weather, *P. parvulus* seems to have multiplied much more rapidly than at Lindenhafen. Most of the liberations around Rabaul and Kokopo were made early in 1939, and by August parasitized larvae and pupae could be found in numbers by most casual inspection. At Wangaramut Plantation, for instance, between 200 and 300 mines were opened, and every one of these contained one or more parasitized larvae and pupae. Other plantations on which the parasites are well established are Ralabang, Ulatava, Keravat and Pondo, showing that its distribution is wide.

METHOD OF BREEDING OF *P. parvulus.*—A very satisfactory method for bulk breeding is as follows:—

Into a large mine, from 20 to 40 prepupae or newly-formed pupae are placed. The ends of the mine are cut and closed with wire clips, and the mine is then placed in a glass tube about 8 inches by 1½ inches with 100 to 200 *P. parvulus* (i.e.

five P. *parvulus* per individual *Promecotheca*) and left for two days. Food is provided in the form of honey very slightly diluted with water, which can be placed on a small piece of blotting paper stuck to the side of the tube, or on the upper surface of the mine in very small droplets. At the end of two days, the prepupae and pupae are removed, and stored in a glass tube 6 inches by 1 inch. If the climate is moist, the tube should be lined with blotting-paper, and adult beetles emerging from unparasitized pupae should be removed daily, otherwise there is a risk of sweating, and consequent fungus attack on the parasitized individuals. The same individuals of *P. parvulus* can be used three or four times for oviposition in fresh lots of *Promecotheca*. Prepupae and pupae are preferred to larvae, as the latter have to be fed before and after parasitism, a process which occupies a great deal of time. These methods were used at Lindenhafen, and produced from 1,000 to 1,500 well-grown wasps per day. Superparasitism was found to be negligible. The developmental period of *P. parvulus* from parasitism to emergence of wasps, was found to be 17 days in Rabaul and 19 days at Lindenhafen, the difference being due to higher mean temperatures at the former locality.

In this connexion it was calculated that the developmental zero for *P. parvulus* was approximately 55° F. (12.8° C.). To determine this figure, parasitized larvae and pupae of *P. papuana* were placed in a refrigerator where the temperature varied from 56° F. to 70° F., averaging between 61° F. and 62° F. Temperatures were taken every three hours in the refrigerator and in the laboratory, and the developmental period for *P. parvulus* in these two situations was noted. From these data the figure for developmental zero was calculated, the results of three trials conducted at different times being 55.5° F., 54.7° F. and 56.7° F.

DESCRIPTION OF *P. parvulus*.—The adult wasp is a black, robust insect, about 1/16th inch in body-length. The three proximal tarsal joints on each leg are white, the fourth joint, like the tibia and femur, being black. Males are smaller than females, and have a greenish sheen on the ventral portion of the thorax, which is not present in the female.

BIONOMICS.—The egg of the wasp is laid, from outside the mine, into the larva, prepupa or pupa of *P. papuana*, the ovipositor of the female penetrating the epidermis of the leaflets in order to reach the host. Oviposition is usually carried on from the under-surface of the leaflet. Where the host is a well-grown, third-instar larva, a prepupa or a pupa, the developmental period of the parasite is shorter than when a first-instar or second-instar larva is the host. At Lindenhafen, 19 to 21 days was the usual period, but some individuals occupied as much as 27 days even in large third-instar larvae. In the second-instar larvae, the period was from 21 to 23 days, with some individuals occupying up to 30 days. At Rabaul, 17 to 19 days was the usual period when large larvae were the hosts. When the life-cycle covers 19 days, the larval period is about eight to nine days, and the pupal period 10 to 11 days. The pupae, when first formed, are white, but darken quickly, until they are finally quite black. The skin of the host turns black about six or seven days after oviposition, in the case of third-instar larvae. When prepupae are attacked by the parasite, they almost invariably reach the pupal stage before dying, and when the pupa darkens it does not become black, but a greyish-brown. Parasitized larvae always feed more voraciously after eggs of the parasite have been laid into them, and in the case of first or second instar larvae, the subsequent feeding period may be as long as 14 days. Feeding by the parasite larvae goes on entirely within the host, and when prepupation occurs, the pupae are packed inside the dried larval or pupal skin.

When fully developed, the adult parasites cut holes in the dry skins of the host, and emerge into the mine, where they then cut holes in the upper epidermis of the leaflet, and escape into the open air. If the portion of the host skin in which the hole is made is pressed against the epidermis, the parasites bite their way straight out, and do not enter the body of the mine. The number of holes made in host and mine varies from one to six.

SUPERPARASITISM.—This has seldom been observed in nature by the writer, but in laboratory breeding, when parasites are placed in a tube with an insufficient number of hosts, it is of common occurrence. If the degree of superparasitism is moderate, the parasites complete their development, but emerge as stunted adults. If it is extreme, development is not completed, parasite larvae and host shrivelling up completely. In one shrivelled third-instar larva, 180 *P. parvulus* larvae were counted. It appears that up to 40 good-sized wasps can develop in a prepupa, pupa or mature larva.

Eurytoma promecothecae.—This parasite was recently described by Ferrière from specimens collected in the Rabaul and Gasmata districts. It is a black wasp, about 1/10th of an inch in body-length, with the distal ends of the tibia yellow, and the tarsi white. The antennae of the male differ from those of the female, the funicle joints of the former being hairy and irregular in shape, while those of the latter are smooth and rounded.

E. promecotheca has been so far recorded only from New Britain, and it appeared to be the main factor in controlling the outbreak of *P. papuana* which occurred along the north-coast road in the Rabaul district subsequent to the volcanic eruption of May, 1937. It would appear that the outbreak was due largely to destruction of a great proportion of the local parasites by the deposits of ash which fell on the plantations in this area, followed by torrential downpours of rain. It was noticeable that those plantations which had suffered most from the ash and the cloudburst were subsequently the most severely attacked by *P. parvulus.*

E. promecotheca is an external parasite of the larva of *P. papuana*, each of the three instars being attacked. The parasite larvae are voracious feeders and, attaching themselves to the sides of the *Promecotheca* larva, they suck its body-fluids until they are fully fed. Feeding is especially heavy during the last day, when the host larva shrinks from almost normal size to a shrivelled husk. The host larvae are paralysed by the adult wasp when the latter lays its eggs, so that they are unable to rid themselves of the parasite larvae.

When the larva of the parasite is fully fed, it moves along the mine and pupates, the pupa being attached to the wall of the mine by a drop of excreta and the cast larval skin. Its colour is at first light yellow, later becoming black. The developmental period, from oviposition to emergence of the adult wasp, is 19–21 days at Lindenhafen, 17–20 days at Rabaul. The adult cuts a hole in the epidermis of the leaflet, usually on the upper surface, and emerges. Maximum longevity of adults in the laboratory was 60 days when not provided with hosts, and 35 days when permitted to oviposit into larvae.

Derostenus sp.—This parasite of the larvae of *P. papuana* occurs widely throughout the Territory, having been recorded from Lindenhafen, Rabaul and Manus. It has not yet been specifically determined, but belongs to the family *Eulophidae*. The adult is of a metallic-green colour, with coxae, tibia and tarsi of all three pairs of legs white. Body-length is about 1/16th of an inch. The adult has a very characteristic habit of running rapidly sideways and of standing on the leaf swaying its body to and fro.

This insect is an internal parasite of the larvae of *P. papuana*. The host does not feed after oviposition by the parasite, and the parasite larvae develop inside the body of the host, which gradually assumes the appearance of a transparent envelope enclosing the parasite larvae. When fully fed, these latter bite their way out of the skin, and pupate in the mine, the pupae being attached to the walls of the mine by a drop of excreta and the cast larval skin. The skin of the host remains distended and transparent. The parasite pupae gradually become black in colour, and normally, the adults emerge and bite their way out of the mine 18–21 days after oviposition by the parent generation. Larval and pupal periods at Lindenhafen were approximately equal.

In the laboratory, *Derostenus* failed to oviposit in prepupae and pupae, and no larvae parasitized by it ever reached the pupal stage. However, in the field it was not uncommon to find pupae parasitized by this species, their appearance being very similar to that of pupae attacked by *P. parvulus*. Three adult females, supplied regularly with food and host larvae for oviposition, lived 25, 26 and 32 days in the laboratory, laying eggs until a day or two before death. When *Derostenus* and *P. parvulus* females were allowed to oviposit into a host larva at the same time, *Derostenus* always won in the competition for food, and only *Derostenus* adults later emerged from the parasitized larva.

10 · *Closterocerus splendens*, Kow.—This Eulophid is about 1/25th inch long, with brilliant metallic-green body and banded wings. It was originally described by Kowalski from the New Hebrides as a parasite of the larva of *Promecotheca opacicollis*, Gestro., but in New Guinea, where it has been found in the Manus, Rabaul and Gasmata districts, it is an egg-parasite. The bionomics of this species have not been extensively studied, but the developmental period from egg-laying to emergence of adult is about 21 days. One parasite develops in an egg of *P. papuana* and an egg-mass may have one or more parasitized eggs. When the parasite is fully developed, it cuts a small hole through the covering of the egg-mass, through which it emerges.

As has been mentioned earlier, *C. splendens*, and to a lesser degree the egg-parasite *Anastatus* sp., are deemed the main factors causing the break in over-lapping of generations in Gasmata and Rabaul districts. At the beginning of egg-laying in one generation of the beetle at Lindenhafen, an attempt was made to estimate the percentage of parasitism of the eggs at different periods. Egg-masses were collected from widely separated portions of the plantations, and the leaflets on which they were laid were kept in water for ten days to allow any parasites which might be in the eggs to develop to a point where they were easily distinguishable. Laying of eggs in the field by this generation of beetles began about 20th May, 1938, and hatching of parasites from these eggs began about 9th June, 1938.

Results of the examinations of eggs collected at three different times are as follows:—

Collected 6th June	30 per cent. eggs parasitized.
Collected 20th June	80 per cent. eggs parasitized.
Collected 3rd July	100 per cent. eggs parasitized.

Hence we see that about six weeks after egg-laying began, 100 per cent. of the eggs were parasitized, and this could explain the restriction of over-lapping of generations to about that period.

Anastatus sp.—This Encyrtid is about the same size as *C. splendens*, and is of a brilliant blue-black colour. It has been hatched from the eggs of *P. papuana* in the Manus and Gasmata districts.

Other Internal Parasites.—One other parasite of the larva, whose habits are similar to those of *P. parvulus*, has been found in Manus, and from the same district and Rabaul, two species of minute hyperparasites of *C. splendens* have been recovered.

Predators.—The pentatomid bug, *Amyotea reciprocus*, Wek., has been recorded as a predator of the adults of *P. papuana* in the Rabaul and Gasmata districts. The adult bug impales the beetles on the end of its extended proboscis, and sucks up the body fluid at leisure.

Ants.—These destroy large numbers of eggs and larvae, and a few adult beetles. Vast numbers of eggs are eaten by *Pheidole megacephala*, Fabr., a small, reddish ant, whose workers have greatly enlarged heads. *Technomyrmex detorquens*, Walk., a black, active ant, with somewhat heart-shaped abdomen, which builds protective galleries under the palm leaflets, using earth-coloured fluff from the crown of the palm, has also been seen to devour eggs.

Various species of ants also attack the larvae and pupae, biting holes to gain access to the mines, or entering through holes previously made by earwigs. *Pheidole megacephala* is again one of the invaders, and other species which attack larvae and pupae in the mines are *Tetramorium guineense*, F., *Monomorium floricola*, Jerd., *Monomorium minutum*, Mayr., and *Tapinoma melanoceohalum*, Fab. *M. minutum* frequently forms its nest within the mine of *P. papuana*. At times, as many as 50 per cent. of the mines collected in the field had been attacked by ants, and up to 30 per cent. of the larvae and pupae destroyed.

The Kurukum Ant.—There has been much discussion in the Territory as to the value of the Kurukum Ant, *Oecophylla smaragdina*, var. *virescens*, F., as a controlling agent for *Promecotheca papuana*. Some planters claim that this ant, if present in sufficient numbers, will prevent extensive attacks by the pest. The
49·5 writer's observations at Lindenhafen provide no support for this view, as the Kurukum was present on the plantation in very large numbers, but was unable to prevent or control the depredations of *P. papuana*. On no occasion has the ant been observed to attack eggs, larvae or pupae of the beetles, and the latter have been observed laying eggs freely on the leaflets of fronds which carried hundreds of Kurukums. The ants have occasionally been seen attacking the adult beetles, and carrying them off to their nests, but these activities are negligible from the point of view of control. It has, however, been noted that certain palms which

have an exceptionally large number of the ants are sometimes less severely attacked than the surrounding palms. A point of importance regarding the habits of *O. smaragdina* is that it exerts a harmful influence by cultivating and protecting aphids, scale-insects and mealybugs.

EARWIGS.—There is a species of earwig commonly found in the crown of coco-nut palms in this Territory, which has not yet been identified. At Lindenhafen, it was found that this earwig commonly entered mines of *P. papuana,* usually making longitudinal slits in the upper surface, and at other times chewing openings in the upper or lower surface. Observation in the laboratory gave no indication that the earwigs attack larvae or pupae of the beetle, and it is thought that they enter the mines for scavenging purposes. Holes made by them provide points of entry for ants.

FUNGI.—During the south-east season in the Gasmata district, from April to October each year, the rainfall is very heavy, up to 70 inches in one month having been recorded, and there are many dull, cloudy days. Under these conditions, the adult beetles are freely attacked by a fungus which has been identified as *Synnematium jonesii,* Speare. Many adults were found dead and fixed to the upper or under surface of leaflets by the white mycelium of the fungus, which also radiates out in all directions from the dead beetle, and covers the body with weblike hyphae. The fungus is not considered to be of great economic importance, as its controlling effect on *P. papuana* appears to be slight.

BACTERIA.—Third-instar larvae of *P. papuana* are frequently found dead in mines, and have the appearance of having been killed by bacterial attack. Their coloration is black, and they lie extended in the mine, the body contents being a black slime. Like the fungus, this bacterial attack is apparently of little economic importance.

DEATH OF LARVAE FROM UNKNOWN CAUSES.—During heavy infestations at Lindenhafen, it has been noticed that there is often a high mortality among first-instar larvae. The larvae are found at the head of the mine, in the feeding position, their bodies being flattened and extended, and normal in colour, showing no sign of bacterial or fungal attack, though there is frequently a blue-mould on the surface of the mine. The cause of this mortality is not known.

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A BALANCED PLANTATION.

(By F. C. Swinbourne, Kieta.)

The plantation which produces only one product is much exposed to market fluctuations which are beyond the control of the planter. This risk is diminished by a diversity of crops, as it is very unlikely that the market will prove unfavorable for all the crops at the same time. The diversity of crops also lessens the risk of a total loss due to pests or climatic disturbances.

It is also difficult to meet the heavy seasonable labour requirements that are necessary with such crops as coffee and cacao except where plenty of casual labour is available. With indentured labour there will be either a surplus during the slack period and, therefore, excessive expenditure, or there will be insufficient labour during the busy season and produce will be lost. By combining such crops with a sufficient area of coco-nuts, an adequate labour force can be permanently engaged, and the copra output will not be seriously affected if this portion of the plantation is periodically neglected during the short periods when the whole labour force is required for the other crops. By stocking some coco-nut areas with cattle, the maintenance costs of the area can be considerably reduced, and, at the same time, fresh meat becomes available.

No hard and fast rules as to the areas to be devoted to each crop can be made, as these must be based on productive costs, but, in general, the areas are proportioned in such a way that any one of the crops can with a fair market cover the running expenses of the whole plantation.

By proper selection of plant, a further economy can be made in cacao driers, and fermenting tanks can be so chosen as to be equally suitable for coffee, although most coffee driers are unsuitable for cacao (Gordon cacao drier). Cement coffee tanks fitted with removable wooden linings are suitable for cacao. The one grading machine does for both crops, only the screens being changed.

This is the system of agriculture adopted in the New Hebrides.

ENTOMOLOGICAL NOTES.

CALCIUM ARSENATE AS AN INSECTICIDE.

The use of calcium arsenate is not nearly as dangerous to man and animals as that of Paris green; it does not possess the caustic characteristics of the latter, but it is undoubtedly attended with a certain amount of danger. Hence, precautions should be taken to prevent the material being swallowed, and also to prevent, as much as possible, the inhalation of the dust in breathing. Absorption through the skin may also take place, and therefore excessive handling of the poison should be avoided. This danger can be reduced by frequent washings. If calcium arsenate is properly made it will not injure plants. In case any burning or scorching of the leaves should be noted, the use of this material should immediately be discontinued, as a comparatively small amount of leaf-burning may easily induce a serious amount of fruit-shedding.

It has been found that, with experienced operators handling the dusting machinery, satisfactory results can be secured from the use of about 5 lb. of calcium arsenate per acre for each application, but a new operator will generally have to be supplied with about 7 lb. per acre, which figure ought to form the basis of calculations.

PREPARATION OF REPTILE SKINS FOR EXPORTATION.

(By R. C. Hutchinson, B.Sc., Department of Agriculture.)

With the present low price of copra, many planters are seeking a new source of income which will not involve them in any initial outlay but which will bring in quick returns. New Guinea is a rich source of reptile skins—lizard, snake and crocodile—for which there is a ready and steadily increasing market. Crocodile skins have been in demand for many years but the lizard and snake skin industry is comparatively recent. Fifteen years ago, reptile skins were used only in the manufacture of luxury articles, the chief use being for the upper leather of high-priced shoes, but to-day reptile skins are used in the production of all types of shoes, bags and fancy leather goods.

At one time it was thought that the use of reptile skins was a matter of fashion, but time has proved otherwise. Because of the wide variety of finish and colour of which they are capable, they provide wide scope for change of fashion. Reptile skins have distinct advantages over sheep, calf or goat skins in that they are stronger, have a good variety of pattern and have better drying and staining qualities.

The collection of reptile skins is organized on a commercial basis in India, Ceylon, Dutch East Indies, Africa, Siam, Brazil, the Philippine Islands and Nigeria, and in some of these countries skins are selected and graded before being exported. From time to time, attempts have been made to propagate captive reptiles for commercial purposes, but generally with little success. In Melbourne, the Government keeps a large number of snakes which are " milked " regularly for their venom.

Preparation of Reptile Skins for the Market.

Crocodile Skins.—Only the belly part of the skin is usable for leather, the hard bony scutes on the back being of no value. The belly part of the skin, including head, whole of the tail and legs, must be taken off at the fullest possible width, leaving about two rows of scutes on each side of the skin. In taking off skins, cut as near to the middle of the back as possible over the legs so as to allow maximum width of skin at the legs; that is, the skins when properly taken off should be as wide at the legs as in the centre of the body. The leg portions should also be left as long as possible, and cut exactly in the middle of the large scales on the top of the leg. In taking off skins, great care must be taken to avoid butcher cuts and spear-holes, as a skin damaged in this way may lose 20 per cent. of its value. All flesh must be carefully removed, the skins properly washed, drained and thoroughly salted.

It is best to ship them in barrels, although bags or bales are suitable. The belly part of the skin must never be folded down the middle. Skins should have the soft part of the sides and legs folded in, keeping the belly flat. When shipping in bags or barrels, the skins after folding must be rolled with the scales outwards, and tightly packed. Only heavy bags should be used, which must be well fastened. If put in bales, the soft part of the sides must be folded in with the flesh outwards, and packed so that the body part will be flat. The bales should be covered with bagging so as to prevent damage to the skins. When shipping in bales, skins must never be folded with the scale side outwards, as this side would be exposed to possible damage during transit.

Snake and Lizard Skins.—Snake skins should be cut down the belly, while lizard skins should be cut down the belly with the tails cut down the back, the heads and legs being opened out so as to obtain maximum spread of skin. The only exception to this is in the case of lizards, which have a fringe down the centre of the back.

After the skin has been removed it should be carefully washed, great care being taken to remove all flesh.

Skins should preferably be shipped in the dry condition, and should be carefully stretched and staked out to their full natural width, great care being taken not to overstretch the skin, which must then be dried in the shade. Dry skins can be packed in cases or bales and the use of napthalene is recommended as a precaution against insect damage. Before drying, it is an excellent idea to put the skins through an arsenic wash to minimize the possibility of insect damage.

Alternatively to being shipped in the dry condition, they may be shipped in the wet salted state, when plenty of ordinary common salt is used. In preparing salted skins it is preferable to first sprinkle the skins with coarse salt, stack them and allow them to drain for twelve hours. They should then be packed in barrels, flesh to grain, with a plentiful application of finely-crushed salt between the skins.

Snake and lizard skins over 8 inches in width bring the best price, although it is impossible to obtain some snake skins over 4 inches. Their value depends upon distinctive markings and grain.

The Department will be only too glad to deal with any inquiries on the further preparation of reptile skins for commercial purposes.

CHEMICAL NOTES.

On the 11th September last, an Agricultural Chemist was appointed to the Department of Agriculture. Since then the Administration has built a chemical laboratory, a balance-room and a store for his use. The necessary apparatus and reagents for the carrying out of general analytical and soil chemistry have been ordered from overseas, but because of war conditions it may be some time before they arrive. In the meantime, the chemist has been engaged in field work and in doing a number of analyses of tinned meats, grasses and legumes. The latter work was carried out at the Health Laboratory at Rapindik. The results of the analyses of nine brands of tinned meat are given hereunder. Six tins of each brand were sampled—

——	Water.	Protein.	Carbohydrate.	Fat.	Ash.
	%	%	%	%	%
Maximum	72	21	5	42	2.3
Minimum	42	11	1.7	11	2.0
Mean	58	15	3	22	2.1

TREATMENT OF WOUNDS IN HORSES AND CATTLE.

(J. A. Ewen, junr., Department of Agriculture.)

When treating animal wounds it is not always necessary or desirable that they be suturated or stitched. In fact, many wounds heal more quickly and cleanly if treated as open wounds.

These open wounds should be kept clean with antiseptic washings only when they are moist, suppurating or discharging. As soon as the wound appears to be drying up, it is preferable to change the treatment to dry dressings. These may be the application of tincture of iodine, or some methylated spirit lotion, such as 1 per cent. picric acid in methylated spirits or, better still, in rectified spirit, followed by the application of a powder (e.g., boracic powder) and loosely covered with a flap of clean cloth to prevent interference from flies and dust. Such a dressing should be repeated two or three times a day.

A wound in the canon or some area not protected with muscle cannot be sutured, on account of the tenseness of the skin at such a part. Here it would be better to use a large syringe and wash out the wound twice daily with clean water and a little antiseptic, afterwards drying with a cloth and applying iodine and boracic powder. The continued use of iodine will prevent the formation of excessive proud flesh.

In cases of severe haemorrhage, it is necessary to tie off the injured blood vessel. To do this, first wash the blood away in order to locate the severed vessel and then grasp it in a pair of artery forceps, so as to stop the bleeding. In the absence of proper forceps, a pair of tweezers may serve the purpose. A suture should then be placed around the vessel. If no silk is available, several strands of horsehair well soaked in spirit can be used.

Haemorrhage from a vessel in the leg could be controlled by placing a tourniquet around the limb; above the part in the case of a severed artery and below the part in the case of a vein. The tourniquet or ligature may be left in place for twenty minutes or more, depending on its tightness. If it has not stopped the bleeding when it is released, it must be re-applied after having allowed a little blood to flow through the tissues first. A tourniquet left too long may do serious damage.

Sometimes a bleeding vessel may be checked by using a silk thread on a needle and passing it through the skin and subcutaneous tissue and in so doing encircle the bleeding vessel and then tie it off. The suture should be removed in four or five days.

Foot injuries are usually in the nature of punctures. The seriousness of the wound depends upon the depth to which the foot has been punctured, and the position and angle of penetration. Around the point of the frog is always a dangerous place, because the navicular joint may be involved. The posterior part of the frog is always a less dangerous place for a puncture, as this can only involve the spongy frog or plantar cushion where infection is not so serious.

A nail wound in the sole of the foot should be opened up with a knife, and packed with wool soaked in pure carbolic acid. Subsequently, daily dressings should be made with 10 per cent. formalin in glycerin.

Injuries to the coronet may be serious by reason of the fact that a deformed hoof will result if the contour of the coronet is broken. Injuries should, therefore, be carefully treated twice each day. Suturing in this situation is desirable or, if it is impracticable, a tight bandage may be employed to hold the loose tissues in place. Zinc ointment can be recommended for coronary band injuries, provided the part is swabbed with spirit before each application and protected from dust and mud with a covering of cloth.

Broken knees are classified into first, second and third degree, depending on the extent of the injury. The first degree injury involves only a lacerated wound of the skin; second degree involves laceration of the skin with contusion of the tendons and cartilages underneath, whilst third degree involves these structures and the bone and joints as well. Treatment must be intensified according to the degree of the injury. In first degree cases, wash well and then use zinc ointment twice daily. In second degree cases, suturing may be desirable together with a spirit lotion and wound powder. In third degree cases, it may be desirable to have the animal destroyed, as an open joint usually leads to a permanent stiffness. If treatment is to be carried out, the joint should be syringed out six or eight times daily with "Eusol", flavine or hydrogen peroxide. In all cases of broken knees and where a pure water supply is available, syringing can be recommended, and this can be followed by the application of the selected antiseptic.

Eye injuries require bathing with warm water and boracic powder twice daily to keep the part clean. Then dry carefully. If the lid of the eye is injured, apply freely yellow oxide of mercury ointment. If the globe of the eye is involved, the cornea or glassy surface will assume a milky or frosted appearance. This calls for 10 per cent. "Argyrol", which can be placed in the eye twice daily with an eye dropper. Cheaper lotions are: 10 or 20 per cent. silver vitellin, 2 or 4 per cent. zinc sulphate, or 1 per cent. silver nitrate.

If the contour of the lids is broken, an attempt should be made to suture the torn edges into correct position, so as to prevent deformity. When treating the eyes of horses, a twitch should always be placed on the nose as restraint. A quiet animal may put up with regular treatment for a day or two, but will eventually object and become troublesome.

BANANA VINEGAR.

Peel the ripe bananas and place them in a jar or large vessel. Pour off the juice each day as it accumulates until there is only the coarse spongy debris left. Strain the juice through a thick piece of brown calico (the calico must be washed first), and let it stand until turned to vinegar. The vessel that holds the juice should not be corked, but have a piece of thin muslin tied over its mouth to let the air in and keep insects out. The time for the juice to become good vinegar depends on the condition of the bananas used. Indifferent fruit makes poor vinegar. A common way to make bananas or mango vinegar is to fill a corn bag with the ripe fruit and hang it over a wooden tub to collect the juice, but the flavour of the vinegar is not so good as if a jar or enamelled vessel were used.—*Jamaica Agric. Society Journal.*

NOTES ON THE COCO-NUT LEAF HISPA, *BRONTISPA FROGGATTI*, SHARP, AND ITS PARASITES.

(*B. A. O'Connor, B.A., B.Sc.Agr., Department of Agriculture.*)

During August of 1939, colonies of *Tetrastichodes brontispae*, Ferr., a *Eulophid* parasite of the larvae and pupae of *Brontispa froggatti*, were imported from the British Solomon Islands. Since then, breeding and distribution of the parasite have been carried on, and at the same time some observations have been made on the bionomics of *B. froggatti*. The information gained is outlined below.

Method of rearing B. froggatti.

In studying the life-history of the beetle, eggs were kept under observation until the larvae emerged, and these larvae were then placed in portions of freshly-cut coco-nut leaflets, which were kept in glass tubes or jars, the openings of which were closed by thin calico held in place by rubber bands. Each day, fresh portions of young leaflet were cut, and the larvae removed from the old leaflet and placed in the new. The same method was used for feeding newly-emerged adult beetles, whose longevity and oviposition habits were the subject of study. In the case of the larvae, the ends of the portion of leaflet were closed with metal clips to simplify the findings of cast skins after each ecdysis. This technique is very simple, and proved quite satisfactory.

The Egg.—The egg is light-brown in colour, dorso-ventrally flattened, rectangular in shape, with rounded ends, and about 1.2 millimetres long and 0.6 millimetres wide. The sides and upper surface have a strongly sculptured network design, the lower surface being plain, often with longitudinal furrows, and the eggs are laid between or inside the tightly-folded young leaflets, with their long axis parallel to the long axis of the leaflet. An egg-mass consists of from one to four eggs placed end to end, each egg being covered with excreta by the beetle, very lightly on the upper surface, and more densely at the ends and sides. Each egg-mass is deposited in a furrow previously chewed out of the leaf by the adult beetle.

The Larva.—The larva hatches through a longitudinal split along the side of the egg. It is at first almost white in colour, except for the more heavily chitinized parts, but later becomes light yellow. Fleshy protuberances are situated laterally on the abdominal segments, and there are spiracles on the first thoracic segment (very prominent) and on the abdominal segments. At the anal end is a strongly-chitinized plate, with a pair of strong, pincer-like processes projecting backward.

It feeds between and inside the unopened leaflets, causing browning and final death of the tissue attacked. Of the larvae kept under observation in the laboratory, eight apparently passed through from three to five instars, and one through six. Feeding ceases for a few hours before and after each ecdysis. At the end of the final instar, there is a prepupal period of about three days, during which no feeding takes place.

The Pupa.—The pupa emerges by the splitting of the prepupal skin along the dorsal portion of the thorax, and is at first white in colour, except for the cast skin, which remains attached to its anal extremity, the pincers pointing backwards as in the larva. Later, it darkens to a yellow-brown tint. On the fifth day of the pupal period, the elytra and eyes are somewhat darkened, and on the sixth and last day, they have become quite black. On the anterior portion of the head, the pupa is finished with three curved spines.

The Adult.—The adult beetles are approximately 8 to 10 millimetres in length and 2 millimetres wide, the males being in general smaller than the females. It is difficult to distinguish between males and females without dissection, the best character being the length of a process which projects forward between the antennae. In the males, this process is more than half the length of the first antennae segment, whereas in the females it is less than half this length. The beetles are flattened with short, sturdy legs. The head and antennae are black, and there is a triangular black spot on the anterior margin of the thorax, immediately behind the head. The thorax and a band about 1 mm. wide on the anterior portion of the elytra are yellow-brown, the remainder of the elytra being black. Ventrally, the thorax is yellow-brown, and the abdomen brownish-black. The forelegs are entirely yellow-brown, and the hind legs brownish-black, while the middle pair have yellow-brown femora and brownish black tibiae and tarsi. The adults feed among the young, unopened leaflets, chewing the tissue in narrow lines parallel to the midrib of the leaflet. As they live much longer than the larvae, they probably do more damage to the infested plant.

Food Plants.—A number of palms serve as host-plants for *Brontispa froggatti,* the known ones being as follows:—

Cocos nucifera—The coco-nut palm.
Metroxylon sagu—The sago palm.
Areca catechu—The areca or betel-nut palm.
Washingtonia filigera—An ornamental palm.
Oreodoxa regia—The royal palm.
Elaeis guineensis—The oil palm.
Thrinax parviflora—An ornamental palm.

Life History.—Only nine larvae were observed from hatching to maturity, and the number of larval instars noted varied from three to six. One larva had three instars, two larvae four, five larvae five, and one larva six. It is possible that some of the cast skins were overlooked, and that the lower numbers of instars are not accurate. Data are appended, the figures being in days—

Larva.	First Instar.	Second Instar.	Third Instar.	Fourth Instar.	Fifth Instar.	Sixth Instar.	Total Larval Life.
No. 1 ..	9	14	14	..	..	..	37
No. 2 ..	8	5	5	20	..	..	38
No. 3 ..	9	6	7	14	..	..	36
No. 4 ..	8	5	5	10	9	..	37
No. 5 ..	4	5	5	6	10	..	30
No. 6 ..	4	5	6	7	11	..	33
No. 7 ..	4	6	5	7	12	..	34
No. 8 ..	4	7	4	7	18	..	40
No. 9 ..	4	5	5½	5½	7	13	40

The sex of the beetles which finally developed from larvae "1" to "4" was not observed, but larvae "5" to "9" developed into males. No careful study has been made of the sex-ratio in *Brontispa froggatti,* but general observations give the impression that there is a great preponderance of males. Copulation, which takes place at intervals throughout the adult life, occurs inside the unopened leaflets.

INCUBATION PERIOD.—The incubation period of the egg is usually five days.

PUPAL PERIOD.—The pupal period is six days.

PRE-OVIPOSITION PERIOD.—Only one lot of five newly emerged adults was kept under observation to determine the egg-laying habits of the beetle. One of these escaped before its sex was noted, so that it is not known whether the five beetles comprised one female and four males or two females and three males. The beetles emerged from pupae on 20th September, 1939, and a single egg was laid on 15th October, giving a pre-oviposition period of 23 days. Two eggs were laid on 22nd October, and from then onwards egg-masses were deposited regularly, about three times a week.

OVIPOSITION.—As there was never more than one egg-mass laid in any one day, it is probable that only one of the beetles was a female. At the time of writing, 163 days after emergence of the beetles, there are three survivors, two males and one female. Forty-four egg-masses have been deposited, comprising 93 eggs, the number of eggs per egg-mass having varied from one to four. Thus the period of oviposition so far has been 140 days, the rate of laying having fallen off considerably during the last two months.

During the last fortnight, 15th-29th February, three egg-masses have been deposited, comprising six eggs. During a period of three weeks, 25th January-15th February, immediately preceding the last fortnight, there was no oviposition.

NUMBER OF GENERATIONS PER YEAR.—Forty-nine eggs had been laid by 3rd December, 1939, so if we take this as approximately the middle of the egg-laying period, we have a figure of 74 days from the first emergence of adult to the middle of the oviposition period. Hence the average length of a generation would be as follows:—

	Days.
Incubation period	5
Larval period	36
Pupal period	6
Pre-oviposition period	74
Total—Egg to egg	121

Thus there would be three generations per year. The shortest time for a generation would be as follows:—

	Days.
Incubation period	5
Larval period	30
Pupal period	6
Pre-oviposition period	23
	64

These figures apply to the Rabaul District, where the mean daily temperature is 80° F.

Parasites of *Brontispa froggatti.*—Two species of native parasites have been found in the Rabaul District, a *Trichogrammatid* egg-parasite, and a *Eulophid* parasite on the larva. The former attacks quite a large proportion of the eggs, but the latter is comparatively rare.

569- *Tetrastichodes Brontispae,* Ferr.—This Eulophid was introduced from Java to the Solomon Islands several years ago, and, by courtesy of Messrs. Lever Bros., colonies were sent from the Solomon Islands to Rabaul in August, 1939. The parasite has not so far been a success in the Solomon Islands, but, having regard to the large measure of control which it exercises on *B. froggatti* var. *selebensis,* Gestro. in the Celebes, it was considered worth a trial here. Breeding of the parasite in the laboratory has proved very simple, and considerable numbers of the wasps have been liberated in the Rabaul, Kokopo, Kavieng and Namatanai Districts. On Wangaramut Plantation, in the Rabaul District, where liberations have been most numerous, scattered pupae parasitized by *T. brontispae* have been collected, showing that the parasite has established itself on a small scale. About 100 such pupae have been found during the last three months. It has yet to be seen whether the parasite will multiply sufficiently to exert any measure of control of the pest.

Method of Bulk Breeding.—To obtain material for bulk breeding of *T. brontispae,* native workers are continually employed in collecting leaflets containing larvae and pupae. These are brought into the Territory, and all pupae four days old or less (i.e., with undarkened elytra) are picked out and used as hosts. Older pupae are too advanced in development for successful attack by the parasite. The larvae are placed in a jar containing coco-nut leaflets as food, and after two days, they are taken out of the jar, and all the pupae formed during the two days are used as hosts.

The selected pupae are placed in a glass tube, 8 inches by 1½ inches, up to 200 pupae being put in one tube. Approximately two wasps per pupa, or slightly fewer, are placed in the tube, and left for two days, after which, the pupae are removed and stored. The parasites are fed on slightly diluted honey, placed in minute droplets on a piece of leaflet. In this way a very high percentage of parasitism is obtained, and good sized wasps emerge when development is completed within the pupae. Developmental period is about eighteen days.

Mites Associated with *B. froggatti.*—Two species of mites are frequently associated with the beetles in the leaflets of infested palms. Sometimes they are found moving freely inside the leaflets, and sometimes they are attached to the body of the adult. Eggs of mites have been found in the furrows left by the feeding of the beetles. One of these mites is strongly chitinized and bright red in colour, and has been identified by Mr. H. Womersley, of the Adelaide Museum, as belonging to the genus *Anoplocelaeno.*

Bacteria.—An occasional larva of *B. froggatti* is found apparently attacked by a bacterial disease. These larvae are red or black in colour, and the body contents have degenerated into slime. One second-instar larva which was being kept under observation in the laboratory was attacked by this disease. One day it appeared perfectly healthy, and the next day it was dead, completely blackened, and with its body contents a slime.

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A SIMPLE PLANTATION LEVEL.

Many jobs on a plantation, such as the installation of a drainage system, require careful levelling. This can be done with sufficient accuracy by the planter with the aid of the simple piece of apparatus shown in Figure 1. This apparatus and the method of using it were first described by H. B. Roe, of the University of Minnesota, and can be made by any amateur carpenter.

The material required is—

A carpenter's 24-in. wooden level of good grade.
Two peep sights.
A pine table 10 inches square with tripod legs.
Several thin pine wedges.
A rod of clear white pine 1½ to 2 inches wide and 10 to 12 feet long, with feet, half-feet and quarter-feet marked on it in blue or black crayon.
Three 3-in. heavy tee hinges with screws.

Table 1 in connexion with Figure 2 will show the simple principle of levelling, but the following absolutely essential points should be kept clearly and constantly in mind:—

For each position of the levelling instrument at least two readings must be taken—a backward sight, or " backsight ", on the last point read at the last preceding position of the level; and a forward sight, or " foresight ", on the new and unknown point. Bear in mind that a backsight is a reading on an old point the relative elevation of which is already known, while a foresight is a reading on a new point of which it is wished to know the relative elevation. The names backsight and foresight, therefore, have nothing to do with the actual direction in which one may be looking, as, after the backsight has been read for any given position of the level, foresights may be read on any number of new points lying in any direction from the levelling instrument.

One should never try to take shots over 6 rods or 100 feet long in any direction with this type of level, and a shorter maximum distance is desirable.

If the bubble is not at centre, bring it there just before taking each reading. The wedges are for this purpose. Set the table in such a position that you do not need to use more than one wedge at a time.

The method of levelling shown in Table 1 and Figure 2 is applicable to any type of levelling instrument with which readings are obtained by sighting at a graduated rod.—R. C. H.

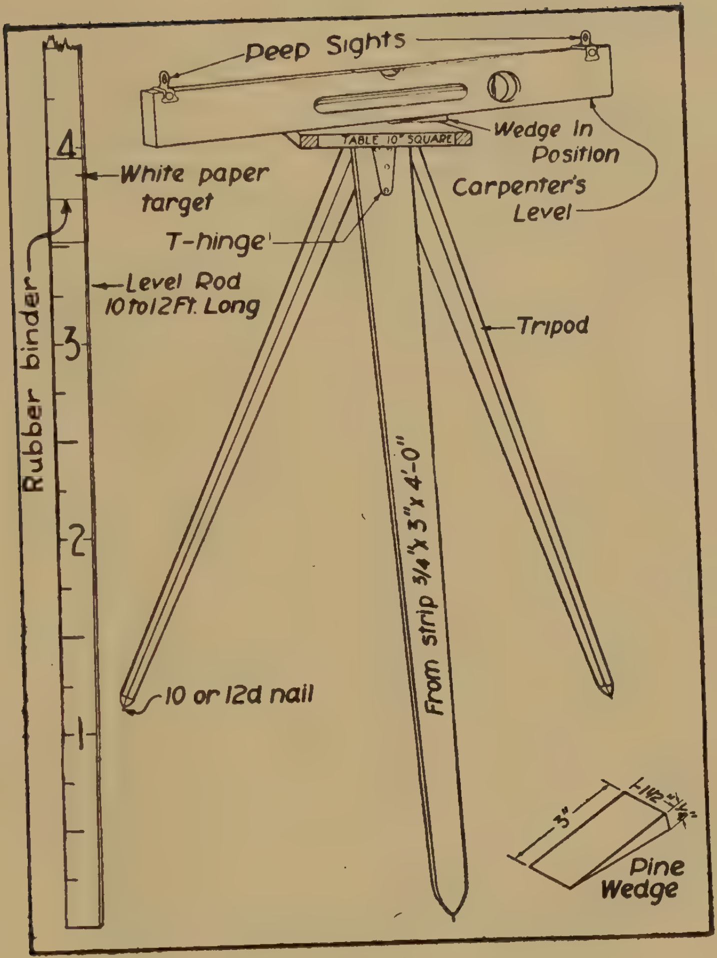

Peep Sights
TABLE 10" SQUARE
Wedge in Position
Carpenter's Level
White paper target
T-hinge
Level Rod 10 to 12 Ft. Long
Rubber binder
4
3
2
1
Tripod
From strip 3/4"x 3"x 4'-0"
10 or 12d nail
3"
1-1/2"
1/4"
Pine Wedge

Figure 1.

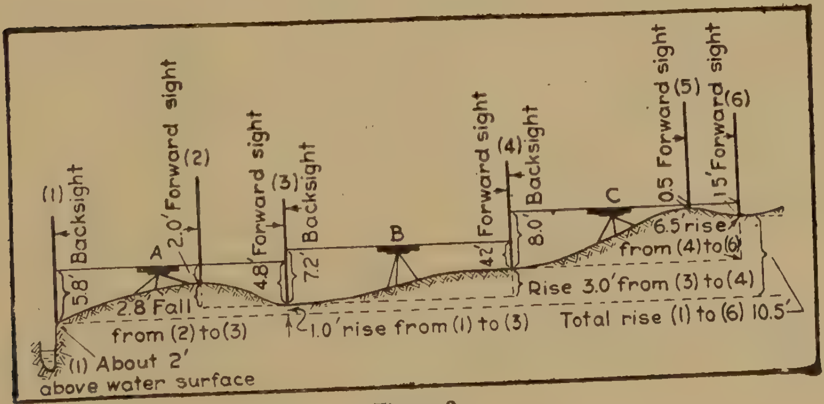

(1) Backsight
5.8'
A
2.0' Forward sight
(2)
2.8 Fall from (2) to (3)
4.8' Forward sight
(3)
Backsight
7.2'
1.0' rise from (1) to (3)
B
4.2' Forward sight
(4)
Backsight
8.0'
Rise 3.0' from (3) to (4)
C
0.5 Forward sight
(5)
1.5' Forward sight
(6)
6.5' rise from (4) to (6)
Total rise (1) to (6) 10.5'
(1) About 2' above water surface

Figure 2.

TABLE 1.—SYSTEM OF LEVEL NOTES FOR DIFFERENTIAL LEVELLING.

Point No.	Position of level.	Backsight.	Foresight.	Difference of level.			Description of points.	Explanation of Computations.
				From last point.	From last Backsight.	Total from point No. 1.		
1	A	5.8					Starting point on ditch bank	
2			2.0	+3.8	+3.8	+ 3.8	Top of knoll ..	All differences = backsight on No. 1 — foresight on No. 2
3			4.8	−2.8	+1.0	+ 1.0	Bottom of pocket	First difference = difference between foresights on No. 1 and No. 2. Other differences = backsight on No. 1 — foresight on No. 3
3	B	7.2						
4			4.2	+3.0	+3.0	+ 4.0	Foot of steep slope	First two differences = backsight on No. 3 — foresight on No. 4. Total difference = 5·8 + 7·2 — 4.8 — 4.2.
4	C	8.0						
5			0.5	+7.5	+7.5	+11.5	Top of knoll ..	First two differences = backsight on No. 4 — foresight on No. 5. Total difference = 5.8 + 7.2 + 8.0 — 4.8 — 4.2 — 0.5.
6			1.5	−1.0	+6.5	+10.5	Bottom of pocket	First difference = difference between foresights on No. 5 and No. 6. Second difference = backsight on No. 4 — foresight on No. 6. Total difference = 5.8 + 7.2 + 8.0 — 4.8 — 4.2 — 1.5 = 10.5.

MANUS METEOROLOGICAL NOTES.

(*B. G. Challis, Department of Agriculture.*)

There is very little meteorological data available for the Manus District. This district comprises all islands and coral atolls of the Admiralty Group lying between 0° 45′ and 2° 57′ south latitude. Manus, or as it is sometimes called, Admiralty Island, is the largest island of the group. Its length from east to west is about 50 miles and it is less than 20 miles in width from north to south. Of the 800 square miles comprising the area of the whole district, Manus, or Admiralty Island, occupies 633 square miles of the group. The island is mountainous and well forested. The highest point reaches about 3,000 feet.

Apart from the Island of Manus the remainder of this district comprises scattered islands of sandy coral nature. The group of islands to the west, known as the Western Islands, are typically low-lying coral atolls which have probably developed by a gradual subsidence of the sea bottom or tectonic movement and conditions favorable for the growth of coral organisms.

These coral atolls have been mainly formed by the work of coral polyps or anemones and the assistance of the accumulated remains of shell-fish and deposits of bird manure. In some cases, drifting marine weed and vegetation has also helped when washed ashore on the windward side of the atolls by the heavy seas which are often experienced in these parts.

It is also interesting to note that the outlying islands of Manus have been subjected to huge tidal waves, due to seismic disturbances, which have swept right over the low-lying islands with devastating effect.

The only Station from which meteorological records have been supplied over a number of years is at Lorengau, the chief administrative centre in the Manus District. Lorengau, situated latitude 2° 20′ south and 147° 20′ east longitude, lies on the southern shore of Sea Eagle (Seeadler) Harbour, which is formed by Los Negros Islands and the north-east coast of Manus Island.

In view of its situation, the climate of Lorengau may be described as possessing the typically characteristic features associated with a coastal station of an equatorial island, i.e., with uniform temperatures, high humidity and copious rainfall. In this district the air flows practically uninterruptedly over the low-lying islands, coral atolls and warm tropical seas. It becomes heavily charged and saturated with moisture, with the consequence that weather conditions are generally oppressive, the only distinguishing seasonal variation being marked by the direction and force of the prevailing winds, which are usually referred to as the north-west monsoon and south-east trade winds. There are, of course, slight diurnal changes in barometric pressures, humidity, cloudiness, rainfall and wind.

The north-west monsoonal period commences slightly earlier in the Manus District than in the more southern districts of New Guinea. It generally lasts from November to March, when a change occurs by the appearance of the south-east trade wind which prevails from about May to October.

It may be noted that there are two shorter seasons of calms or feeble winds which are associated with thunderstorms and variable weather known as "inter-monsoon" and "inter-trade", which mark the change-over from the monsoon to the trade winds during October to November and between April and May.

The prevalence of the north-west monsoon corresponds with the winter of the northern hemisphere. Actually the monsoon wind is a continuation of the north-east trade wind originating in about 30° North of the Pacific Ocean, but whose course is deflected by the optimum rotation of the earth's axis at the equator, with the result that around the Admiralty Group the winds prevail more from the west or north-westerly direction. It is interesting to note that during the so-called south-east season the prevailing winds blow more from the east than true south-east.

Slight land and sea breezes may be felt around the coast of the main island of Manus, where they tend to blow off shore at nights from about 11 p.m., and on shore from about 9 a.m. The usual lull at sundown is experienced if the monsoon or trade winds are not blowing strong enough to overcome these local winds, of which the on shore or sea breeze is the stronger.

An examination of the rainfall tables will reveal that there is no definite wet or dry season. Precipitation occurs evenly throughout the calendar year. Generally it may be assumed that the average rainfall throughout the district would be between 100 and 150 inches. The average annual rainfall at Lorengau for the past 23 years is 142.87 inches.

The extreme temperature range registered at Lorengau is 96° F. to 66° F., while the average maximum daily temperature is 88.8° F., with an average minimum of 72.3° F., resulting in a mean daily temperature of 81.1° F.

The average relative humidity figures for 9 a.m., 3 p.m. and 9 p.m. readings are 87 per cent., 72 per cent. and 91 per cent. respectively.

More detailed climatological data is set out in the following tables:—

MONTHLY AND YEARLY TOTALS AT MANUS DISTRICT.

(In Points), Station—Lorengau.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Total.
1917..	872	24	638	1,342	676	503	708	877	424	1,305	1,490	368	9,227
1918..	761	2,076	1,200	1,321	1,403	2,030	2,445	1,755	1,135	1,137	993	551	16,807
1919..	771	1,204	1,168	2,225	876	1,684	1,303	151	128	1,480	1,688	1,397	14,075
1920..	1,283	892	786	1,832	959	1,347	1,793	1,402	869	1,136	967	2,656	15,922
1921..	1,394	398	697	1,545	718	656	925	1,234	1,104	979	1,796	1,689	13,135
1922..	1,140	933	1,257	1,349	967	1,146	2,220	1,551	1,317	1,146	1,511	851	15,388
1923..	1,359	451	1,048	851	1,223	2,038	1,815	1,890	1,192	1,009	810	597	14,283
1924..	945	1,578	1,051	553	373	848	1,173	453	512	299	293	1,254	9,332
1925..	459	1,217	895	1,031	478	810	1,332	958	1,299	381	787	243	9,890
1926..	2,000	68	602	776	527	687	1,609	2,335	490	490	1,010	1,001	11,595
1927..	1,451	1,149	1,468	1,190	730	1,219	*	*	*	*	*	*	..
1928..	*	*	*	*	*	*	1,709	1,201	1,114	2,156	433	748	..
1929..	1,105	613	812	1,087	1,106	1,301	3,346	2,175	825	1,112	1,726	1,630	16,838
1930..	1,530	1,390	1,725	1,740	862	1,542	1,177	1,351	1,463	1,153	920	1,403	16,256
1931..	1,403	1,287	1,670	965	1,501	1,184	1,570	1,955	939	1,669	1,090	1,106	16,339
1932..	1,301	1,847	1,188	1,585	1,115	2,097	1,905	1,495	1,872	1,454	1,151	1,701	18,711
1933..	1,237	2,390	1,347	1,658	1,017	814	671	731	745	366	1,174	515	12,665
1934..	714	378	643	1,830	991	958	1,497	2,150	1,909	1,370	847	2,221	15,508
1935..	1,123	922	1,694	1,290	1,392	1,568	1,869	758	596	*	412	651	12,275
1936..	1,216	1,727	1,671	345	1,339	572	1,231	2,647	978	1,663	1,905	800	16,094
1937..	1,448	512	945	983	836	527	2,417	3,061	819	898	451	1,422	14,319
1938..	2,360	753	912	1,268	650	1,050	1,430	761	589	229	1,158	1,761	12,921
1939..	1,573	2,454	1,917	1,547	1,163	1,435	1,479	1,860	1,998	1,476	931	610	18,443
Average ..	12.47	11.03	11.52	12.87	9.50	11.83	16.19	14.89	10.14	10.91	10.70	11.44	142.87

* Not recorded.

CLIMATOLOGICAL DATA.—TEMPERATURE.

(Station, Lorengau.—Latitude 2° 2′ S., Longitude 147° 19′ E.; North Coast, Manus.—Height above Mean Sea Level, 10 Feet.)

Month—1939.	Mean.		Monthly Average 1939.	Highest Maximum.	Date.	Lowest Minimum.	Date.	Amount of Clouds Means of 9 a.m. and 3 p.m.	Days Without Rain.
	Maximum.	Minimum.							
January	87.1	72.6	79.8	91.5	10th	70.0	19th	5.9	9
February	86.5	72.7	79.6	91.0	7th	70.5	25th	6.5	8
March	86.4	72.8	79.6	90.0	13th	71.0	8th	6.3	11
April	88.0	72.1	80.0	92.0	10th	70.0	2nd	6.3	11
May	87.9	71.8	79.8	92.0	12th and 13th	71.0	24th	6.4	10
June	87.4	71.6	79.5	92.0	6th and 7th	70.5	13th	5.5	9
July	86.5	71.9	79.2	91.0	19th and 31st	68.5	9th and 24th	5.9	11
August	86.7	73.4	80.0	93.5	3rd	71.0	27th	6.4	13
September ..	87.3	72.9	80.1	90.5	25th	71.0	13th	5.8	15
October	88.1	73.4	80.7	91.5	19th	71.0	1st	6.6	15
November.. ..	87.2	73.4	80.3	93.0	13th	72.0	5th and 13th	6.2	12
December ..	87.5	74.1	80.8	91.0	6th	73.0	31st	6.1	18
Average ..	87.2	72.7	79.9	..	..	..	..	6.2	11.8
Extremes ..	88.1 October	71.6 June	80.8 December	93.5 3rd August		68.5 9th and 24th July		6.6 October	18 December

CLIMATOLOGICAL DATA.—HUMIDITY AND RAINFALL.

(Station, Lorengau.—Latitude 2 ° 2′ S., Longitude 147° 19′ E. ; North Coast, Manus.—Height above Mean Sea Level, 10 Feet.)

Month, 1939.	Humidity.			Rainfall Monthly 1939.	Average Rainfall Since 1917.	Greatest Monthly Rainfall.	Year.	Least Monthly Rainfall.	Year.	Wet Days Monthly 1939.	Wet Days Average Since 1917.	Greatest fall in 24 hours.	
	Mean 9 a.m.	Mean 3 p.m.	Mean Monthly.									1939.	Date.
January ..	95	91.0	93.0	15.73	12.47	23.60	1938	4.59	1925	22.0	18.4	2.24	2.1.39
February ..	91	79.0	85.0	24.54	11.03	24.54	1939	0.24	1917	20.0	14.8	6.05	10.2.39
March	87	79.0	83.0	19.17	11.52	19.17	1939	6.02	1926	20.0	18.1	4.55	18.3.39
April	87	76.0	81.5	15.47	12.87	22.25	1919	3.45	1936	19.0	18.1	3.72	26.4.39
May	91	79.0	85.0	11.63	9.50	15.01	1931	3.73	1924	21.0	18.7	1.61	23.5.39
June	91	72.0	81.5	14.35	11.83	20.97	1932	5.03	1917	21.0	15.5	2.48	29.6.39
July	95	72.0	83.5	14.79	16.19	33.46	1929	6.71	1933	20.0	20.1	2.67	23.7.39
August ..	91	76.0	83.5	18.60	14.89	30.61	1937	1.51	1919	18.0	14.2	3.90	22.8.39
September ..	91	79.0	85.0	19.98	10.14	19.98	1939	1.28	1919	15.0	16.5	4.21	16.9.39
October ..	91	72.0	81.5	14.76	10.91	21.56	1928	2.29	1938	16.0	15.0	3.97	21.10.39
November ..	91	79.0	85.0	9.31	10.70	19.05	1936	2.93	1924	18.0	17.0	1.44	29.11.39
December ..	91	91.0	91.0	6.10	11.44	26.56	1920	2.43	1925	13.0	17.8	2.58	1.12.39
Average ..	91	78.7	84.9	15.37	11.96	..	..	..	..	18.6	17.0	3.28	..
Extremes ..	95 January, July	72.0 June, July, October	93.0 January	24.54 February, 6.10 December	16.19 July, 9.30 May	33.46 July	1929	0.24 February	1917	22.0 January	20.1 July	6.05	10.2.39

METEOROLOGICAL RECORDS.

Maty Island (Manus District).

(Wuvulu) 1° 42′ S., 142° 50′ E.

Month.	1934.		Rainfall Average, Nine Years.	Wet Day Average, Nine Years.
	Rainfall.	Wet Days.		
January	5.66	16	10.61	20.3
February	8.12	15	9.40	15.4
March	10.72	14	11.16	16.0
April	10.61	17	12.73	18.9
May	7.88	20	13.46	17.4
June	7.65	21	11.83	18.6
July	12.56	19	16.29	20.1
August	28.60	22	16.02	20.5
September	24.29	17	12.65	17.0
October	9.15	15	10.34	14.9
November	12.42	11	12.30	15.3
December	25.71	25	13.20	18.2

Rainfall for 1934—163.37 inches. Average annual rainfall for nine years, 1926–1934—149.99 inches.

Mokareng (Manus District).

2° 2′ S., 147° 27′ E.

Month.	1938.		Rainfall Average, Three Years.	Wet Day Average, Three Years.
	Rainfall.	Wet Days.		
January	19.38	20	15.73	17.0
February	8.98	18	6.02	14.5
March	8.39	22	12.57	22.0
April	10.43	15	8.42	14.0
May	..	..	5.19	15.0
June	12.73	17	7.03	15.3
July	13.30	21	12.97	20.3
August	4.30	16	12.94	20.7
September	4.51	11	8.32	13.3
October	1.85	9	9.01	15.3
November	5.22	12	23.57	14.3
December	..	..	13.04	15.0

Rainfall for 1938—89.09 inches. Average annual rainfall for three years, 1936–1938—134.81 inches.

Pelleluhn Island (Manus District).

1° 8′ S., 144° 25′ E.

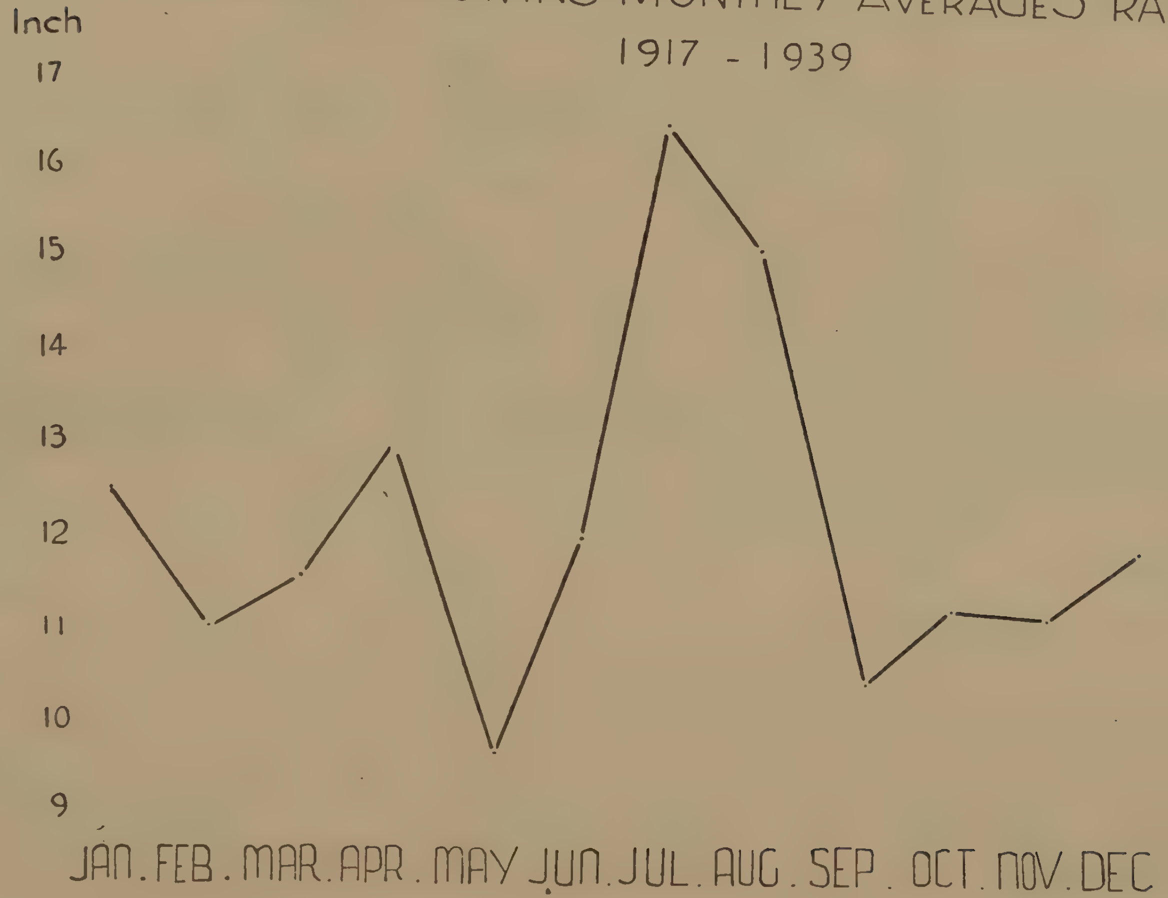
Month.	1939.		Rainfall Average, Ten Years.	Wet Day Average, Ten Years.
	Rainfall.	Wet Days.		
January	17.77	17	9.93	15.3
February	18.59	19	7.93	12.7
March	18.17	20	10.21	13.3
April	16.00	18	10.21	13.5
May	8.60	17	9.04	14.4
June	15.75	19	10.09	13.6
July	10.60	18	11.67	15.4
August	18.70	15	13.81	16.6
September	12.40	16	10.52	13.2
October	22.00	18	8.84	12.2
November	16.30	16	10.43	14.0
December	8.90	16	12.71	15.8

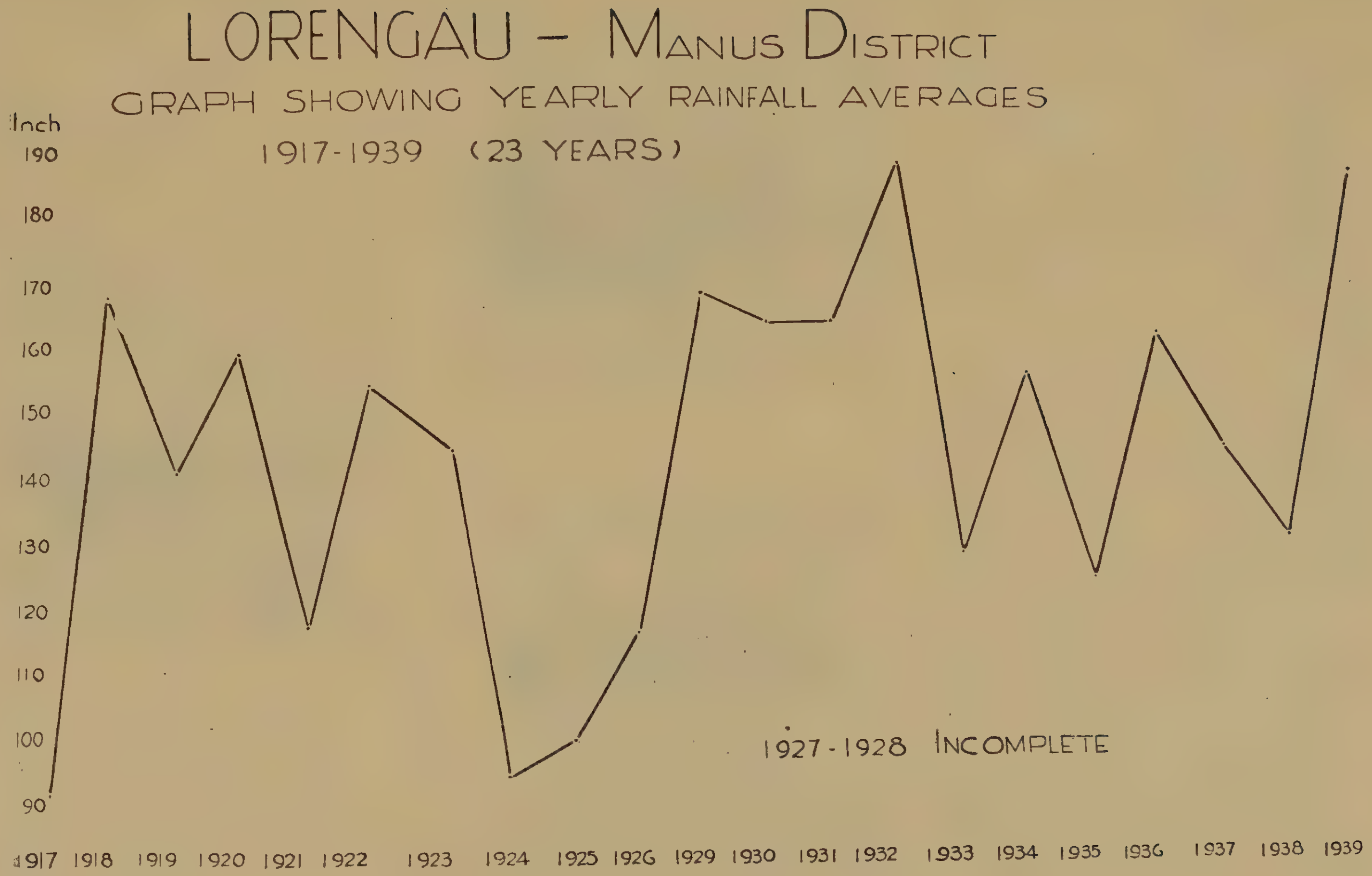
Rainfall for 1939—183.78 inches. Average annual rainfall for ten years, 1930–39—125.39 inches.

LORENGAU - MANUS DISTRICT

GRAPH SHOWING MONTHLY AVERAGES RAINFALL —

1917 - 1939





LORENGAU — MANUS DISTRICT

GRAPH SHOWING YEARLY RAINFALL AVERAGES

1917-1939 (23 YEARS)

BOTANICAL NOTES.

BANANA MUTATION.—A SECTORIAL CHIMERA CAUSED BY MUTATION (IN THIS CASE LOSS) IN A COLOUR FACTOR.

A very interesting specimen of bananas was sent to this department by Mr. F. B. S. Hislop from the Bulolo gold-fields, on the mainland of New Guinea. The hand of bananas consisted of a total of 92 bananas in seven bunches attached to the nodes of the rachis (fruit stalk). The bananas on the proximal bunch, however, were small and only partly developed.

The striking characteristic which prompted the sender to observe this particular hand of bananas was that the fruits and, in fact, the whole of one main shoot, were divided into two almost equal component areas, half being red and half being green. This parti-coloured effect was obviously a somatic (body) colour mutation, known to geneticists as a chimera.

This phenomenon is depicted in photographs 1, 2 and 3, which well illustrate the colour differences from different aspects.

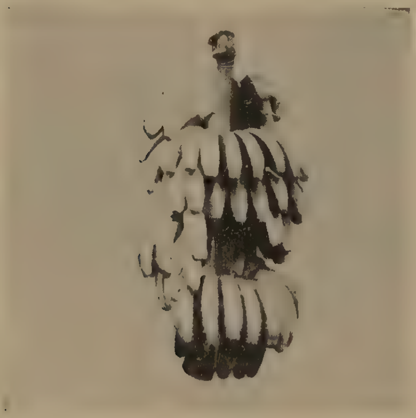


Figure 1.

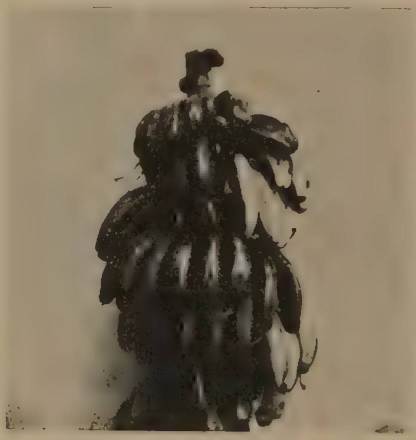


Figure 2.

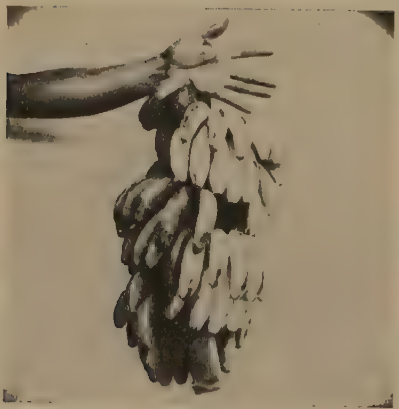


Figure 3.

The original banana sucker from which the chimera developed was originally cut from a whole-coloured, red banana-stool. It was planted at Baiune Station, 2 miles from Bulwat, Bulolo, at an elevation of 1,900 feet, and the age of the plant from which the banana was received was about two years and three months.

The true identity of the variety of bananas is not known for certain, but it was believed to be a Cavendish type, judging from the size of the banana and the yellowish flesh when ripe.

According to the original sender the colour division (chimeric condition) existed right from the base to the top of the main shoot bearing the hand of bananas, being divided into two component areas, half red and half green, and both the stalk and the leaves (also probably the flowers) showed this distinct division into two practically equally divided areas. This colour variation also continued from the main corm right through the stalk of the rachis (fruitstalk) (*see* photograph No. 1 showing colour division at base of rachis).

A more striking differentiation was that some of the single bananas borne on the nodes at the actual point of colour division were parti-coloured (*see* photograph No. 2). Later inquires showed that the main stool was still in existence but the new shoots did not display the chimeric condition again. A sucker obtained from approximately the area where the division occurred also had a decided tendency to throw to the red factor.

All of the bananas were examined for seed content but were seedless (parthenocarpic) so separate perpetuation by seed of the green and red sides of the one bunch was not possible. Nevertheless, as bananas are grown from corms or suckers, it was quite possible for this chimera to increase vegetatively.

Counts were made of the number of red, green and parti-coloured fruits present, with the following results:—

Red bunches, 3½ (1 small proximal);
Green bunches, 3½.

One green bunch contained one red banana. Another green bunch contained one red and one parti-coloured banana (one-quarter green banana, the rest being red).

One red bunch had one parti-coloured banana, but no whole coloured green bananas were seen on the red bunches.

The bunch marked as one-half red and one-half green also comprised one-half red and one-half green parti-coloured banana.

SUMMARIZED COUNTS.

Bunches.	Bananas.	Ratio.
3 red	54 reds	18.3
2 green	34 greens	11.3
1 half-coloured	3 parti-coloured red-greens	1

It will be seen that there has been a loss of a red colour factor involved, hence, from the banana breeders' point of view, the red colouration in bananas is dominant to green and this change to green is a recessive mutation. The green coloured bananas could be expected to breed true in hybridization work, while the red colouration would be the segregating factor.

It is doubtful whether the ratios shown have much genetical significance, as the numbers of bananas showing the different colourations were largely influenced by the position of the bunch on the fruit stalk. There were more bunches on the red side of the shoot than on the green side and where the sectional chimera passed through one bunch, it was practically cut in halves as far as colour was concerned. It is largely from analogy and other reasoning, which indicates that a single mendelian factor is involved.

This colour variation undoubtedly originated in a single terminal growth or body cell of the original sucker during the course of cell division (i.e., in the meristematic tissue). This cell division was aberrant or irregular so that the colour passed through the chromosomes to the nucleus of one-half of the divided cell, but not to the other side. Thus, in all of those cells derived from the original coloured half of the terminal body cells, a red colouration was perpetuated, while all those cells derived from the half which lost this colouration remained green. From the layman's point of view, an occurrence of this nature gives a good demonstration of one means by which new varieties of bananas may originate in nature, without actual cross-pollination. There is no need to explain this type of occurrence to the botanist or geneticist, as loss of colour factors are the most common natural chimeras found in nature. They occur very frequently in citrus fruits (especially in the orange and lemon), also in fruit such as apples, pears, grapes, olives, and flowers such as gladiolus, poppies, sunflowers, dahlias and many other types of plants.

In a great many of theso colour chimeras or variations, it is possible to trace it through the fruit, down the branch and the stem to a point where it has apparently originated in a single cell, such as in the case just described. Nevertheless, there are few chimeras described which are more striking than the one featured here.

Occurrences such as that described have turned the attention of investigators to the fundamental causes of these seemingly inexplicable phenomena, because they are so important in the study of variation and heredity.

This brings one to the study of growth substances or hormones (e.g., wound stimuli), radiation and internal nutrition, subjects which are too complex for the purposes of this article. It might be pointed out, however, that actual mechanical wounding of the terminal cells by cutting back, insect injury, &c., may lead to the release of certain wound stimuli (chemical growth substances) which may cause irregular cell division and sports to develop. It has also been stated that excessive exposure and radiation at the growing point may have a similar effect such as at high levels.

The fact that distribution of the colouration on the bananas corresponded with that on the vegetative tissue shows the essential body cell (vegetative) derivation of the fruiting tissue and also the intimate connexion beween the conditions governing growth and fruiting.

The importance of studying individual buds and cells (i.e., cytology) by plant physiologists and geneticists is also clearly indicated. The practical utility is hard to define without reference to the whole subject of growth substances and heredity studies. Even now it is possible to produce certain useful mutations artificially by the use of X-rays and in some plants, like the tomato, by continuously cutting them back until sprouting shoots occur so that new varieties originate.

In conclusion, it is explained that the main objective of this description of what may be considered by planters as a relatively freak occurrence is to show that studies of specimens such as those sent in may have real practical importance. There is also on hand a rare specimen of flowering aberration in a coco-nut which it is hoped to describe later on, so that its importance can be indicated.

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TERRITORY OF NEW GUINEA.

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COMMUNICATIONS.

All communications should be addressed to the Editor, the *New Guinea Agricultural Gazette*, Department of Agriculture, Rabaul.

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EDITORIAL NOTES.

THE subject of copra deterioration with age is one which has received considerable discussion of late. It has been thought by some that the length of time which copra can be stored is limited to a few months, while others were of the opinion that it will keep indefinitely.

The results of experiments which have been in progress in this Department for some months indicate that copra can be kept for a considerable number of years without deterioration providing it is properly dried in the first place. This is confirmed by the following findings.

In a copra store in Rabaul there are some hundreds of bags of copra at least three and a half years old. Some of these were recently opened, the copra examined and found to be almost as good as the day it was made, and still of sufficient quality to be exported as first class. Other batches of copra—fifteen, twelve, and nine months old—were also examined with the same result.

If copra is to be stored for a prolonged period it will gradually lose or gain water until it is at last in equilibrium with the moisture of the atmosphere; but, if the copra contains considerable water, moulds and insects will ruin it before it has dried to the equilibrating point. On the other hand, if the copra is well dried, no damage will be caused during the slight absorption of moisture which takes place.

As the result of experiments in this Department, it would appear that for prolonged storage the copra should contain less than 7 per cent. moisture, although this figure is only tentative. The best Rabaul hot-air copra usually contains approximately 5 per cent. moisture, so that, if it is properly stored, it should keep for a considerable period without deterioration.

COPRA DETERIORATION DURING STORAGE AND SHIPMENT.*

(*By F. C. Cooke.*)

Introduction.

Copra is a perishable commodity. The amount of deterioration and loss of actual copra which can occur varies in different circumstances. Commencing with a given quantity of fresh coco-nut meat, the ultimate quality and the quantity of copra received at the mill depend on four factors:—

(*a*) Care exercised in the preparation of the product.
(*b*) Moisture content of the freshly prepared copra.
(*c*) Treatment during bulking, storage and transport.
(*d*) Length of time elapsing between production and milling.

Period of Storage.

The time elapsing between production and milling is dependent on locality of production, difficulties of collection and local transport, seasonal variation in crop, freight charge fluctuations, amount of cargo space available in ocean-going steamers, and the state of the copra market.

In the case of Straits copra, when shipments keep pace with purchases, the normal interval is just over two months, but, in exceptional circumstances, the copra may be held in store for two or three months prior to shipment. Thus, for example, during the Great War it was impossible, on occasions, to obtain cargo space from certain ports and, more recently, a long period of low prices resulted in considerably reduced shipments. When such situations arise, stocks accumulate in the warehouses, and small dealers, and even producers, may be forced to hold up their copra.

Table I. provides a rough detailed estimate of the time taken to pass copra from the small-holder in this country to the miller in Europe.

TABLE I.

Approximate times for various operations which may occur between producing and milling small-holders' copra.

Operation.	Time.
	Days.
House storage	1 to 7
Shophouse storage	0 to 7
Local dealers' stores	0 to 7
Road, river or coastal transport	1 to 4
Warehousing at export centre	0 to 150
Ocean shipment	30 to 40
Bulk storage before milling	3 to 14
Total	35 to 229

---

* From the *Malayan Agricultural Journal*, Vol. XXVII., No. 11, November, 1939.

Some of the operations shown therein may be omitted or all may be included in full, so that small-holders' copra which is exported may take from one to seven months to reach the oil mill.

Estate copra is nowadays generally exported from the estate direct to Europe on a through bill of lading and little more than a month need elapse between production and milling. Copra milled locally is seldom kept for more than a month after production.

Copra Trading.

In the case of the small producer, a small quantity of "raw", half-cured or somewhat under-dried loose copra may perhaps be kept for as long as a week before the collector calls or delivery is arranged. Whenever possible the copra is sold without delay. These small parcels of copra are bulked by a succession of buyers—the shopkeeper, the transporter, the small local dealer, and ultimately the export dealer and shipper—into consignments of gradually increasing size.

Since he usually buys his copra at a flat rate from producers and then may sell it on a dry-weight basis to the merchants, the local dealer will usually lay the wettest copra out in the sun for further re-drying, particularly when it is likely to pay him to delay re-sale. Conversely, when copra is sold at a flat rate, cases have occurred where the lowest grades of copra have been deliberately moistened by the seller to increase the weight.

The bulked copra which ultimately arrives at the export centres, Singapore, Penang and Port Swettenham, from the different production centres is variously dry and exhibits different features and degrees of deterioration depending on the treatment accorded to the product and effect of weather conditions on production, storage and shipment. It is for this reason that it is described as "mixed" copra, i.e., a mixture of f.m.s. and f.m. copra;* the geographical origin is added to this description, e.g., Kelantan "mixed" copra, and this serves to identify the quality, since each coco-nut district has its particular standard of quality, or a recognized f.m.s./f.m. ratio for "mixed" copra.

The small-holders' bulked copra now being received from most districts is reasonably dry and of high quality and the "ratio" for copra from these districts has distinctly improved; nevertheless some of the copra coming generally from the more remote regions still continues to be of inferior quality. In exceptional cases, such copra is wholly f.m. quality and is offered in a "raw" condition.

Conditioning of Copra by Storage.

"Raw" or half-cured copra, if produced near the export centres, is usually received at the export warehouses in a fresh condition, but that from the more distant and inaccessible regions, or from those places where collection is difficult, is more often badly deteriorated, except when the local dealers or shippers have re-dried the product before sending it to the export centres.

Fresh "raw" copra, as received, is warm, has a pale-yellow, gummy surface, is free from mould, and exudes a not unpleasant yeasty odour. Deteriorated "raw" copra is hot, black, soft, matted and glutinous, insect-ridden and dirty; it is covered with a thick layer of wet slime and black mould and has a revolting sour smell.

---

* The terms f.m.s. and f.m. are expressions of quality and denote respectively "fair merchantable sundried" and "fair merchantable", the latter being the inferior quality.

All bags of "raw" copra are usually emptied without delay, and the contents built up into a huge stack.

Continuous records show an initial rise in temperature inside such a stack from 35° to 52° C. in about three hours. Subsequently the temperature declines slowly to about 38° C. on the eighth day of storage and after that even more gradually to about 30° C. in about three weeks, by which time the moisture content has been reduced to between 4 and 5 per cent. During this period the temperature of the stack rises each night when the warehouse doors are closed.

The condition of fresh "raw" copra which has been expeditiously reconditioned may be surprisingly good in spite of previous superficial development of bacterial slimes. In one instance, although a sample of such copra after reconditioning had a dirty greyish-yellow appearance, it showed little internal discoloration while only 4 per cent. of the pieces were deeply corroded and there were only 8 per cent. of "smalls". The copra had a not unpleasant smell and the acidity of the contained oil was only 0.8 per cent., calculated in terms of lauric acid.

"Raw" copra which has been permitted to deteriorate seriously before warehousing cannot be satisfactorily reconditioned. After warehousing, the whole of the copra is internally discoloured, the range of colour being light-brown to black. The bulk of the pieces are very deeply corroded and all are in process of breaking down into small fragments. There is very high percentage of "small", foreign matter and dust, and the acidity of the contained oil, calculated as lauric acid, is usually in excess of 5 per cent. Such copra is therefore below Straits f.m. quality and requires to be "brightened" with copra of somewhat better quality before shipment.

Irrespective of their condition, the various consignments of "mixed" copra received at the warehouses are usually all made up into large stacks of loose or bagged copra as described above. In this way, copra is self-dried by its own heat of decomposition,* the contained moisture being reduced from anything between 7 and 25 per cent. to between 4 and 7 per cent. according to season. A relatively stable and reliable product is thus obtained which may be sorted, blended and graded for export. The length of storage required depends principally on the moisture content of the copra on receipt, but occasionally self-drying may be curtailed to make up a consignment when copra is short. Dry copra requires about a week's storage, fairly dry copra about fourteen days, and very wet copra as much as three weeks, before it is ready for shipment.

Blending and Bulking for Shipment.

Copra is exported in two grades, Straits f.m.s. and Straits f.m. After warehouse drying the various lots of "mixed" copra are either up-graded by the removal of defective pieces or down-graded by the removal of good pieces whichever is necessary to produce the required grade. Occasionally there is no picking over, since a parcel may be used to brighten up or bring down a consignment of bulked copra to the desired standard. The method of bulking is to build up, layer upon layer, the various parcels of copra from different sources, so that blending and mixing takes place when this stack of loose copra is broken up and the copra shovelled into sacks. The copra then remains in bags until shipment can be arranged.

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* For discussion on heat of decomposition *see* Special Bulletin No. 28, General Series, Department of Agriculture S.S. and F.M.S. Copra Deterioration, pp. 20 to 22.

During ocean shipment a certain amount of self-heating again occurs in the copra, which is subjected to considerable pressure and disturbance due to the movement of the ship. The individual bags of copra enter the ships' holds at about air temperature (28° C.); subsequently there is a slow daily rise for three days to about 35° C., or more, according to the efficiency of ventilation in the holds and the condition of the copra; ultimately when more temperate regions are reached the temperature gradually declines.

The merchant shipper who prepares the copra for export takes full responsibility for the ultimate quality of the copra on arrival and for any serious loss in weight in transit.

The foregoing remarks do not usually apply to estate copra which is nowadays mostly of uniformly good quality and can, in consequence, be shipped direct from the estate to Europe without any warehousing, inspection or blending being necessary. Such copra is classified as Straits f.m.s. although for copra to be forwarded without inspection or warehousing it has, of necessity, to be above normal quality to avoid the possibility of subsequent disputes and arbitration. It is obvious that the interval between production and milling will be much reduced with direct shipment and the amount of handling will also be considerably less. For these reasons, copra of this type usually obtains a small premium.

The agents of deterioration during transport and storage are yeasts, bacteria, various moulds and insects, and the heat of decomposition, but it is the moisture present in the copra which makes deterioration possible and determines which (if any) of the agents may operate and the extent of the deterioration and loss which occurs.

The individual effects of these several agents cannot be separately determined, as it is not practicable to restrict deterioration to a single factor. Nevertheless, it is possible to determine, by experiment, the total deterioration and loss which may be expected to occur with a given set of conditions. Even then it is still not possible to follow normal trading, transport, storage and blending practice since copra under observation has to be periodically sampled and cannot therefore be mixed with other copra.

Storage Trials.

In order to ascertain the extent of the loss which occurs when different types of copra are kept for long periods under normal conditions of storage, two storage trials have been carried out with the six different types of produce copra shown in Table II. These may be regarded as representative of the different types of copra produced in Malaya. The majority of estates nowadays produce copra corresponding to grade W1, while the best small-holder producers offer grades W1 and W2. Nevertheless, copra of grade W3 does still continue to be made in one or two inaccessible regions and this degenerates, according to the absence of care in production or to the treatment accorded to it by the local dealer, to yield copra corresponding to grade R1, R2 and R3.

TABLE II.

Types of copra used in storage trials.

Lot.	Initial Condition.	Moisture Content.
		Per cent.
W1	Dry smooth white copra	About 8
W2	Fairly dry white copra	9 to 12
W3	Half-dried " raw " white copra	About 20
R1	Dry unscorched " red " copra	About 8
R2	Fairly dry " red " copra	9 to 12
R3	Half-dried " raw red " copra	About 20

The various lots described in Table II. were each prepared from 100 nuts collected from the same estate. The " red " copra was produced by allowing bacterial decomposition to be initiated prior to drying and to continue to develop subsequently through deliberate carelessness during drying. All the copra was carefully kiln-dried over open smokeless fires.

Two methods of storage were used, the period of storage being two months in each case. In one, Trial " A ", the six lots of copra were sent immediately after manufacture for bulk storage in a Singapore warehouse with copra of corresponding qualities (continuous warm storage). In the other, Trial " B ", there was an initial period of fourteen days during which the six lots of copra were kept in a cool place as individual isolated bags (cool-storage). Subsequently this copra was warehoused as in the first trial.

It was not possible in either of these trials to simulate exactly the handling and movement, and the conditions of temperature and pressure to which copra is normally subjected during local trading, warehousing and ocean shipment. The conditions of the first trial may nevertheless be considered roughly to correspond to the treatment accorded to the copra from large producers, while those of the second trial are meant to simulate the treatment accorded to the copra made by small producers, amounting to about two-thirds of the total copra produced in Malaya.

The various lots of copra were each examined, weighed and sampled before, during, and after storage. These samples were analysed for moisture, and the acidity of the contained oil was also determined. At the conclusion of the period of storage, the amount of " smalls " and dust associated with each lot, which in practice is reckoned as copra, was also ascertained and the copra was examined qualitatively by a Singapore merchant.

Thus it was possible to estimate the true loss of copra which occurs during storage and to measure the amount of deterioration under the various conditions stated.

The comparative results of the two trials are shown in Tables III. to IX. inclusive—

TABLE III.

TOTAL LOSS IN WEIGHT DURING STORAGE. (WEIGHT CORRECT TO NEAREST ¼ LB.)

Lot.	Trial A. Continuous Warm Storage.			Trial B. Cool and Warm Storage.		
	Original Weight.	Loss in Weight.	Loss.	Original Weight.	Loss in Weight.	Loss.
	lb.	lb.	Per cent.	lb.	lb.	Per cent.
W1	63.75	1.50	2.3	56.25	3.25	5.8
W2	68.75	5.50	8.0	64.25	6.00	9.3
W3	78.75	18.75	23.8	79.75	20.50	25.7
R1	60.50	3.25	5.3	58.50	3.25	5.6
R2	67.50	6.00	8.9	64.25	10.00	15.6
R3	78.50	17.00	21.6	74.50	20.25	27.2

The total loss in weight in storage includes not only loss of free moisture, but also loss of actual dry copra through decomposition. The loss is expressed as a percentage of the original weight of copra, including contained moisture. It is to be noted that in the transportation of "raw" copra (W3 and R3) about a fifth by weight of the consignment consists of avoidable moisture, thus increasing freight costs.

The final moisture content of the copra after warehouse drying was between 4 and 5 per cent. in all cases.

TABLE IV.

LOSS OF ACTUAL COPRA DURING PREPARATION AND STORAGE. (WEIGHT CORRECT TO NEAREST ¼ LB.)

Lot.	Trial A. Continuous Warm Storage.				Trial B. Cool and Warm Storage.				
	Original Dry Weight.*	Preparation Loss.	Storage Loss.	Total Loss.	Original Dry Weight.*	Preparation Loss.	Cool Storage.	Warm Storage.	Total Loss.
	lb.	lb.	lb.	Per cent.	lb.	lb.	lb.	lb.	Per cent.
W1 ..	59.25	N	N	N	52.00	N	0.50	1.50	3.8
W2 ..	61.75	N	1.75	2.8	56.50	N	N	1.50	2.6
W3 ..	63.25	N	6.00	9.5	65.00	N	6.75	2.25	13.9
R1 ..	55.25	1.50	0.25	3.2	55.25	1.50	2.00	1.00	8.1
R2 ..	59.25	1.50	0.25	3.0	58.25	1.50	5.25	1.25	13.7
R3 ..	61.25	1.50	2.50	6.5	58.50	1.50	5.25	2.00	15.0

N = nil or negligible.

* The figures in these two columns were determined by converting the actual weight of each lot according to its moisture content.

It is perhaps surprising that lot W3 ("Raw" white copra) Trial A showed a greater loss than lot R3 ("Raw" red copra) of the same trial. It was also more rank and infested by insects. This is doubtless because smoke adheres readily to the surface of slimy "red" copra and this film of smoke serves to provide a temporary check to insect attack and bacterial deterioration during the short period before warehouse-drying. Where there is prolonged cool storage before warehousing, as in Trial B, the agents of deterioration are able to operate freely once the protective smoky film has been broken down and penetrated.

The high spoilage for lots W3 and R3 of Trial B is not exceptional. Such extensive deterioration and breakdown can and do occur in practice.

In the extreme, with abnormally prolonged storage of deteriorated "raw" copra, maintained continuously in a wet condition, it is even possible for the loss to be in the neighbourhood of 99 per cent., since long-sustained insect attack and progressive decay due to moisture produced during decomposition may leave only fragments of brown testa, or skin.

Attention is next drawn in Table V. to the high production of "smalls" resulting from the storage of "raw" copra in Trial B. Individual pieces of copra were so deeply corroded as a result of deterioration during the period of cool storage that they readily broke down when pressure was applied to the copra or if the copra was disturbed.

TABLE V.

REDUCTION OF COPRA TO "SMALLS" AND "DUST".

Lot.	Trial A. Continuous Warm Storage.				Trial B. Cool and Warm Storage.			
	Original Dry Weight.	"Smalls."	"Dust."	Percentage Spoilage.	Original Dry Weight.	"Smalls."	"Dust."	Percentage Spoilage.
	lb.	lb.	lb.		lb.	lb.	lb.	
W1	59.25	N	N	N	52.00	0.75	N	1.4
W2	61.75	0.25	N	0.4	56.50	0.75	0.25	1.8
W3	63.25	0.75	0.25	1.6	65.00	10.25	0.75	16.9
R1	55.25	N	N	N	55.25	1.00	N	1.8
R2	59.25	N	N	N	58.25	0.50	0.25	1.3
R3	61.25	0.75	0.25	1.6	58.50	11.75	0.75	21.3

In Malaya any "smalls" and "dust" are included and sold as copra, but their presence in any quantity is a serious matter to the miller. Seriously deteriorated copra will suffer further size reduction during shipment and transport to the oil mills, so that a larger surface is exposed to the agents of deterioration and losses of small pieces and dust will occur when the material is transported loose in conveyors.

It is to be observed from Table VI. that the development of acidity is not serious during the period of cool storage when the loss of copra is greatest (W3, R1, R2, and R3 of Trial B). Samples W3 in both trials had a revoltingly sour smell.

TABLE VI.

ACIDITY OF OIL IN STORED COPRA. (CALCULATED AS LAURIC ACID.)

Lot.	Trial A.	Trial B.	
	After 2 months' Warm Storage.	After Cool Storage Only.	After Cool and Warm Storage.
	Per cent.	Per cent.	Per cent.
W1	0.17	0.11	0.30
W2	0.22	0.16	0.32
W3	2.61	0.81	3.11
R1	0.25	0.17	0.47
R2	0.58	0.15	0.39
R3	2.20	0.40	6.12

Table VII. gives the average depth of discoloration in the stored samples of copra. Actually the extent of deterioration varied considerably from piece to piece. Some pieces showed only localized deterioration whereas in others discoloration was complete.

TABLE VII.

AVERAGE EXTENT OF DISCOLORATION IN COPRA ON STORAGE.

Lot.	Trial A.	Trial B.
W1	All white	One-third
W2	One-third	One-half
W3	Three-quarters	Total
R1	One-sixth	One-third
R2	One-quarter	One-half
R3	Three-quarters	Total

The six lots of stored copra were inspected by a leading exporter and the results of this examination are given in Table VIII. It will be seen that the various lots were classified with respect to the export grades Straits f.m.s. and Straits f.m. as is the case with all copra after it has been stored and when it is ready for blending.

TABLE VIII.

EFFECT OF STORAGE ON QUALITY OF COPRA.

Lot.	Quality of Copra after Storage.	
	Trial A. Continuous Warm Storage.	Trial B. Cool and Warm Storage.
W1	Straits f.m.s. ++	Straits f.m.s.
W2	Straits f.m.s. +	Straits f.m.s.
W3	Straits f.m. +	Straits f.m. —
R1	Straits f.m.s.	Straits f.m. ++
R2	Straits f.m. +	Straits f.m. +
R3	Straits f.m.	Straits f.m. —

The ratings above and below the recognized export standards indicate to what extent each parcel needed to be blended with inferior or superior copra before export. Two plus and one plus mean "well above" and "above" respectively, while a minus indicates that a consignment is below the export standard for the specified quality. It will be noted that with only one exception, viz., lot R2, each lot from Trial A is superior to the corresponding lot from Trial B.

Sub-grade copra, i.e., f.m. — can easily be recognized when the copra is purchased from the dealer and so can be and is usually penalized, but parcels of copra which may ultimately prove to be superior to the two recognized export grades receive no special premium above the recognized quotation, although they have an added value when the various parcels are being blended for shipment.

Finally, Table IX. gives the comparative values of the various types of copra derived from the same theoretical amounts of fresh coco-nut meat. The necessary calculations were based on the losses of actual copra as scheduled in Table IV., the ultimate quality of the material (whether f.m.s., f.m. or sub-grade), and the following prices of copra per picul*:—

	Per picul. $
Estate copra, shipped direct	3.40
Straits f.m.s.	3.30
Straits f.m. copra	3.00
Sub-grade copra	2.70

TABLE IX.

RELATIVE MARKET VALUES OF PRODUCE OBTAINED FROM THE SAME THEORETICAL WEIGHT OF COCO-NUT MEAT.

Lot.	Trial A. Continuous Warm Storage.			Trial B. Cool and Warm Storage.		
	Final Dry Weight.	Price of Copra per picul.	Value of Copra.	Final Dry Weight.	Price of Copra per picul.	Value of Copra.
	Piculs.	$	$	Piculs.	$	$
W1	100	3.40	340.00	96.2	3.30	318.00
W2	97.2	3.30	321.00	97.4	3.30	321.00
W3	90.5	3.00	271.50	86.1	2.70	232.00
R1	96.8	3.30	319.00	91.9	3.00	275.70
R2	97.0	3.00	291.00	86.3	3.00	258.90
R3	93.5	3.00	280.50	85.0	2.70	229.00

The figures show clearly the extent to which deterioration can affect the value of the copra. Thus in the case of Trial B, lots W3 and R3, the value of the copra is only about two-thirds that of the highest grade.

Conclusions.

(i) Copra is subject to loss and deterioration during storage and transport, unless properly prepared and promptly warehoused.

(ii) Such deterioration proceeds most rapidly at air temperatures and is reduced or checked at higher temperatures and temporarily by a film of smoke on the surface of the product.

(iii) Loss and deterioration are very considerable in the case of "raw" half-dried copra if there is delay before it is suitably bulk stored.

(iv) When there is serious deterioration, the individual pieces of copra readily break down to yield "smalls" and "dust".

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* 1 picul = 133–136 lb.—Ed.

Discussion.

Since the foregoing investigations reveal that half-cured copra is such an unstable and unsatisfactory product, it may seem strange that well in excess of half the world's copra is produced in this condition while, here in Malaya, much of the imported copra and some even of the copra produced in this country still continues to be of this quality. It is an unfortunate fact that such copra has a trade value and so is saleable. It offers peculiar opportunities for profit-making to the small dealer which are not realizable with a more stable and reliable copra. Where all producers offer the same low grade of product, they cannot readily appreciate that they are not obtaining the maximum return from their palms.

It is not appreciated sufficiently, if at all, that not only are deterioration, previous to, during, and immediately after production, and the moisture content taken into account in the prices paid by local traders for "mixed" copra but also that the ruling or basic price, paid in any one district, is a reflection of the ultimate general quality of the copra from that particular district, and includes adequate compensation to the dealer to discount all loss and deterioration which normally occur with such copra during transport and storage subsequent to production.

Small dealers have never been found willing to encourage the production of a stable and reliable product as they claim that small lots of such copra are of little use to them. In those districts where a market for low-grade "raw" copra is firmly established it is therefore quite useless for an individual small producer to make drier and better copra, since he then obtains less copra, which is nearly always paid for only at the current local price. The most he can ever expect in return for his extra trouble is a price strictly proportionate to the reduction in moisture, but this allows no extra profit whatever for improved appearance and quality.

The best copra is usually made and the best local prices are paid in the immediate neighbourhood of the export centres and the oil mills. This is because little time normally elapses between production and storage in bulk, and thus any "raw" copra which may be produced will not seriously deteriorate subsequent to sale. It is thus possible for a high standard of quality to be established, and in such circumstances low-grade copra is exceptional and is likely to be penalized if offered.

The worst copra is usually produced in the more inaccessible regions whence parcels can be shipped only at irregular or long intervals, with consequent long delay before bulk storage. Despite the desirability of producing only dry copra in such regions, there is here, as elsewhere, an unfortunate natural tendency for the quality of copra produced to decline during periods of low or falling prices, particularly the latter, since drying is then liable to be curtailed so as to obtain a greater weight of copra or to make a quick sale while prices are still high.

This is a trend which it is not easy to reverse for it is not reasonable to expect individual producers to lose money by producing copra which is above the local standard of quality and dryness. It is frequently stated that producers are apathetic but it would be more correct to say they are helpless in the face of existing trading conditions.

INSECTS ASSOCIATED WITH THE COCO-NUT PALM.—I.

(By J. L. Froggatt, B.Sc., Entomologist, and B. A. O'Connor, B.A., B.Sc.Ag., Assistant Entomologist, Department of Agriculture, Rabaul.)

INTRODUCTION.

In this and subsequent articles it is intended to deal with all insects which have been found in direct association with the coco-nut palm in this Territory. Much of the information has been given in previous articles, but now all available data, including sections that have not been previously published, are gathered together in this series.

Some of the insects listed are of considerable economic importance, while others are only of such status for a relatively short period during the growth of the palm, or, in some cases, the insects apparently do little or no damage, although found commonly on the palm.

A full account of the research work carried out on the problem of the "Coco-nut Tree-hoppers", *Sexava* spp., over the period 1930-38 is now presented, and as this insect is the most serious pest of coco-nuts in this Territory, it will be considered first.

In the following list of insects found in association with the coco-nut palm, the species are grouped in accordance with that portion of the palm with which they are associated:—

INSECTS ASSOCIATED WITH THE COCO-NUT PALM IN THE TERRITORY OF NEW GUINEA.

Foliage and Mid-rib of Fronds—

ORTHOPTERA ..	*Tettigoniidae* ..	*Sexava novae-guineae*, Brancs.
		Sexava nubila, St.
	Gryllidae ..	*Cardiodactylus novae-guineae*, Haan.
COLEOPTERA ..	*Hispidae* ..	*Promecotheca papuana*, Csiki.
		Brontispa froggatti, Sharp.
		Brontispa simmondsi, Mlk.
		Brontispa longissima, Gestro.
		Oxycephala papuana, Gerst.
	Curculionidae ..	*Rhabdocnemis obscura*, Boisd.
		Diocalandra frumenti, F.
RHYNCOTA ..	*Coccidae* ..	*Aspidiotus destructor*, Sign.
		Mytilaspis sp.
		Chionaspis sp.
	Aleyrodidae ..	*Aleurodicus destructor*, Mackie.
		Aleurocanthus cocois, Cork.
LEPIDOPTERA ..	*Hesperidae* ..	*Telicota bambusae*, Moore.
	Lyonetiidae ..	*Decadarchis ophiocypha*, Meyr.
		Opogona Taochroa, Meyr.
		Erecthias flavistriata, Wals

Spathe—

Rhyncota	*Pentatomidae*	*Axiagastus campbelli*, Dist.
Lepidoptera	*Pyralidae*	*Tirathaba rufivena*, Walk.
Coleoptera	*Dynastidae*	*Xylotrupes gideon*, L.
		Scapanes grossepunctatus, Sternb.
	Curculionidae	*Meredolus cocotis*, Mshll.
		Barystethus cleutsi, Heller.
	Cetonidae	*Lomaptera batchiana*, Thoms.
		Panglaphyra nigerrima, Voll.
		Panglaphyra douboulavi, Thoms.
		Poecilopharis emilia, White.
		Ischiopsopha wallacei, Thoms.
	Lucanidae	*Eurytrachelus egregius*, Moll.
		Metopodontus bison, Ol.
		Cyclommatus speciosus, Boid.
		Dorcus intermedius, Gestro.
Hymenoptera	*Apidae*	*Halticus* sp. on blossom.
	Formicidae	*Oecophylla smaragdina virescens*, F. in head of palm.

Trunk, Head of Palm and Bole—

Coleoptera	*Dynastidae*	*Xylotrupes gideon*, L.
		Scapanes grossepunctatus, Sternb.
		Trichogomphus semmilinki, Rits.
		Papuana laevipennis, Arr.
		Oryctoderus nanus, Arr.
	Curculionidae	*Rhyncophorus papuanus*, Kirsch.
		Rhyncophorus schach, F.
		Sparganobasis subcruciata, Mshll.

The major pests in the insects listed above are—

Foliage—
- *Sexava novae-guineae*, Brancs.
- *Sexava nubila*, St.
- *Promecotheca papuana*, Csiki.
- *Brontispa* spp.

Trunk, &c.—
- *Rhyncophorus* spp.
- *Papuana laevipennis*, Arr.
- *Sparganobasis subcruciata*, Mshll.
- *Xylotrupes gideon*, L.
- *Scapenes grossepunctatus*, Sternb.
- *Trichogomphus semmilinki*, Rits.

SEXAVA SPP. (COCO-NUT TREE-HOPPERS).

Outside the Territory of New Guinea, the only record of *Sexava* as an economic pest is in that portion of the Netherlands East Indies, bounded by the coast of Dutch New Guinea, the Aroe Islands, Amboina, Boeroe, Soela Islands, Halmahera and Talaud Islands; the species recorded are *S. nubila* and *S. coriacea*. There are portions of this area in which the pest seldom, if ever, assumes serious proportions, and there are others in which it is of definite economic importance. Even in the worst infested areas there is a period of severe attack followed by a period of very slight activity.

In the Territory of New Guinea, *Sexava* spp. are fairly generally distributed, with the exception of the Kieta District (the northern end of the Solomon Island group), where they are as yet unknown. In some districts, or even portions of districts, they are always present to a slight extent, but seldom, if ever, cause any material damage to the palms, while there are others in which they periodically cause severe defoliation, resulting in loss of production for one and a half to two years. It must, however, be stated that in the latter cases, when the palms do recover and come into bearing again, the crops carried are very heavy ones; unfortunately, there are no figures available to compare the actual loss of production during the infested period with the increased crop after recovery.

As a general rule, the records show that *Sexava* infestation is always worst, and of most frequent occurrence, in areas in which no regular dry period occurs during the year, this factor causing desiccation of eggs and also very adversely affecting the first instar nymphs in particular.

In the Territory of New Guinea two species are recorded, *Sexava nubila*, St. and *Sexava novae-guineae*, Brancs., the former occurring on New Ireland, New Britain and in the Madang District and New Hanover areas, and the latter in the Manus District and on New Hanover.

The adults and nymphs are essentially arboreal in habit, living in the head of palms, where they shelter on the undersurface of the pinnae of the fronds during the day; they are able to cling very firmly to the foliage, but are often dislodged by high winds. Feeding usually occurs at night, but on dull days it may be observed during the afternoon.

In 1931 detailed field research was instituted into the problem of *Sexava* on coco-nuts with the appointment of an Assistant Entomologist, who was first stationed in the Manus District, the worst infested "hopper" district in the Territory; the field laboratory was later moved to New Hanover, then to the Arawe District of New Britain, and finally back to Manus.

In 1933 the senior author was sent to Amboina, in the Netherlands East Indies, where three egg parasites of *Sexava* spp. had been recorded by Dr. Leefmans. These parasites were *Leefmansia bicolor*, Waterst., *Doirania leefmansi*, Waterst., and *Ootetrastichus dubius*, Waterst. The first of these had been reported by Leefmans as being the most promising, and a satisfactorily large colony of it and a smaller one of *D. leefmansi* were bred in Amboina, and successfully brought by direct transport to Manus, where breeding and study of life-history, &c., was immediately begun. At this time, the only egg parasite of *Sexava* known in this Territory was *Doirania leefmansi*, Waterst., which had been bred from eggs collected on New Hanover by the senior author in 1930. > xxiv, 202.

The rate of increase of population of *Sexava* in any area, is relatively slow, as shown by the very long life cycle and manner of breeding. This insect never occurs as a huge swarm in a similar manner to the locust plagues in many parts of the world. On one plantation kept under regular observation for more than twelve months, there was a heavy infestation in April at one end of the plantation, and by November of the same year, the pest had spread over a considerable portion of the whole area, but had nowhere become serious, while the portion at first severely attacked was then showing definite signs of decrease in activity of the pest, new foliage on the palms showing little or no signs of feeding.

Life-history and Habits.

THE EGG.

The eggs are always deposited singly, although several may be found close together, as though laid in succession by the one female; they lie, micropilar (head) end upwards, just under the soil surface or to a depth of half an inch. When freshly deposited, they are a deep biscuit colour with flattened sides; the colour deepens to dark brown and the sides swell out as development proceeds. The eggs at first measure about 9 mm. in length, increasing to 11 mm. before maturity. In some parts, there are considerable numbers of eggs deposited in the fibre in the crown of the palms, and in the epiphytic growths on the trunks of the palms; this is most prevalent on New Hanover, and to a slightly less extent in the Manus District. When the infestation is severe, eggs may also be found in the rotting bases of fronds, in coco-nut skins, rotten logs and amongst palm roots lying above ground at the base of the palms.

In the plantations, oviposition apparently always takes place at night, but where the insects are caged up in the laboratory, this act may occur during the day. In the field, the sites most favoured for deposition of eggs are bare surfaces of moist, loosely compacted sandy soil, dry ground being avoided. The orientation of the egg in relation to the surface of the ground does not necessarily affect the emergence of the baby "hoppers".

The period for the eggs to reach maturity shows considerable variation, ranging from 45 to more than 100 days, although the majority of nymphs emerge in 45 to 60 days from deposition. From a large series of observation, the average number of eggs laid by a single female in her lifetime has been 30, while as many as 49 have been recorded.

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With eggs laid in cages, the percentage of fertility (determined by dissection) has been about 91, with a percentage of hatching of 69 to 86; eggs collected in the field over the same period gave percentage of fertility about 76, and the hatching percentage about 74.

The eggs can withstand a very wide range of abnormal conditions without entirely losing their fertility. Eggs were kept in very dry soil for 110 days, and then the soil was moistened; within ten days after watering, approximately 40 per cent. of the eggs yielded normal nymphs. In plantations, however, where not only dryness but heating of the soil occurs a much heavier mortality by desiccation is found to take place. Eggs kept in moisture saturated, but drained, soil, gave a normal percentage of hatching.

Eggs laid by the one female on the same night usually mature at about the same time, but those laid on different, even successive nights, show wide variations in reaching maturity.

In order to determine the danger of dispersion of the pest by birds, feeding on female "hoppers" with mature eggs in the ovaries and passing these in the faeces, a number of dissections were made, and eggs apparently ready for deposition were incubated in the ordinary way, using others separated from soil in breeding cages as controls; in no case was a single nymph bred from the former.

THE NYMPHS.

When the egg reaches maturity, the shell splits along the dorsal ridge for about one third of its length, and then at right angles to this line for about two-thirds of the circumference, thus freeing the vermiform larva, which pushes its way to the surface and sheds its skin; these may be seen on the surface of the soil in emergence jars in the laboratory, although not so readily noticed in the field. The nymphal moult then takes place immediately. The head and thorax are freed first, and by twitching of the legs and body the nymphal skin is gradually cast off backwards; the antennae may still be contained in their sheath at this stage, but these are freed by the insect passing them slowly through the mouth parts by bending the head downwards and then backwards; this portion of the operation occupies about three minutes. The antennae are at first flaccid, but within one minute of being freed, they harden and are capable of normal movement. The full emergence occupies about five minutes. Emergence normally takes place in the early evening, the nymphs commencing the ascent of the palms the same night.

Development of the nymphal stages takes place by a series of moults of which there are six or, in some cases, seven, in the males, and seven in the females; the act of moulting always occurs at night. Two types of male nymphs were observed during the research work carried out at Manus, one having six instars, and the other seven; the former have been called "micropterous" and the latter "macropterous". The macropterous males, in the fifth instar, develop wings and elytra which reach back over the third abdominal tergite, the elytra being superimposed on the wings. The micropterous males, in the fifth instar, only have small wing-buds which do not reach back over the abdominal tergites, and which are situated one in front of the other. In the sixth instar, the micropterous type attains a development similar to that reached by the macropterous type in the fifth instar while the latter type develops much larger wings and elytra, and corresponds to the sixth instar of the nymphs noted on New Hanover.

The average duration of the instars observed at Manus are given in the following table:—

—	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Total Length Range.	Average.
Macropterous male ..	13.8	13.3	11.5	13.0	14.2	17.7	..	78– 91	83.5
Micropterous male ..	13.8	13.3	11.5	13.0	13.1	14.1	18.1	91–117	96.0
Female	13.8	13.3	11.5	13.0	14.5	15.4	19.4	90–124	100.9

It has been noticed that the numbers of nymphs caught by adhesive bands is much greater for the first two or three nights after rain, and it appears probable that climatic conditions play a considerable part in regulating the rate of emergence of the nymphs from the eggs.

The following description of the various instars, prepared by Mr. N. E. H. Caldwell, B.Sc., formerly Assistant Entomologist in this Department, has proved a satisfactory key for the differentiation of the instars, with the addition of the modification for the macropterous male nymphs given above:—

Males—

1st. Wing rudiments. A very slight differentiation of the sides of the meso- and meta- thorax is discernible.
Genitalia. The hypandrium may be seen as two small buds on the ninth abdominal segment.

2nd. Wing rudiments. Quite easily distinguishable, the elytra being pointed and narrow, and the wings being much broader and still rounded at the tip. Both at right angles to the longitudinal axis of the body.
Genitalia. The hypandrium now takes the form of two prongs directed straight back, with little or no basal portion.

3rd. Wing rudiments. The wings are now pointed, the elytra slightly curved and both slanting slightly backwards, thus making the anterior margins longer than the posterior. There may be a trace of venation on the anal area of the wing.
Genitalia. The hypandrium now definitely consists of a basal portion and a bifurcated portion, of about equal length, the whole reaching about half way along the paraprocts, and with the points of the bifurcated portion incurved.

4th. Wing rudiments. Both wings and elytra now slanting backward markedly. The elytra are decidedly curved, and there may be one or two raised lines thereon. The wings now somewhat longer than the elytra, and the venation is quite distinct in the anal area.
Genitalia. The points of the hypandrium are strongly incurved, and the whole reaches to the divergence of the paraprocts or beyond.

5th. Wing rudiments. The rudiments are now lying along the back, the wings overlying the elytra and both reaching to about a third of the way along the second abdominal segment. Longitudinal veins well developed on the wings, but no cross veins, only two or three longitudinal on the elytra and cross veins can be seen on holding up to the light.
Genitalia. Hypandrium reaches back beyond the paraprocts, and as far back as the cerci.

6th. Wing rudiments. The wings occupy the same relative positions, are considerably increased in size and extend back to at least the end of the third abdominal segment. Both longitudinal and cross venation well developed.
Genitalia. The hypandrium now extends beyond the end of the body and two short styles have appeared, one on the end of each prong of the bifurcated portion.

Females—

1st. Wing rudiments The same as in the male of the same stage.
Genitalia. Two pairs of buds can be distinguished, one on the eighth and one on the ninth abdominal segments. Under high magnification, the posterior pair resolve into pairs.

2nd. Wing rudiments. The same as in the second male stage, except that the wings are still rounded.
Genitalia. The valves of the ovipositor have increased considerably in size. The lateral and posterior valves can now be distinguished closely appressed in pairs. All valves are the same length, but the anterior pair reach only to the base of the others.

3rd. Wing rudiments. Both pointed, but the elytra not curved, both slanting slightly backward. No venation.
Genitalia. Another marked increase in size, the lateral and posterior valves being more clearly distinguishable, but still closely appressed, while the anterior pair are relatively slightly longer.

4th. Wing rudiments. Both rudiments slanting backward, the elytra somewhat curved, and there is a suggestion of venation on the anal area of the wings.
Genitalia. All the valves are about the same length and closely appressed to each other thus forming a compact organ, which is about one tenth of an inch long, and reaching to the end of the paraprocts.

5th. Wing rudiments. The elytra markedly curved, slightly shorter than the wings, clearly-visible venation on the anal portion of the wings.
Genitalia. The ovipositor had doubled its length and now reaches to about the end of the body.

6th. Wing rudiments. The rudiments are now lying along the back and corresponding to the fifth male stage.
Genitalia. The ovipositor is now about half an inch long, and extends for a considerable distance beyond the body.

7th. Wing rudiments. These are in the same position as in the sixth male stage.
Genitalia. The ovipositor is now an inch or slightly more in length.

One of us (B.A.O'C.) has worked out a further means of separation of the various instars by measuring the hind tibiae, as per the appended table.

IDENTIFICATION OF INSTARS BY MEASUREMENT OF HIND TIBIAE.

(Measurements in 1/40th".)

Instar.	Males.		Females.	
	Range.	Average.	Range.	Average.
First	13–14	13.3	13–14	13.3
Second	17–18	17.5	16–18	17
Third	21–25	21.7	20–22	21.4
Fourth	26–31	27.3	24–27	26.1
Fifth	34–37	35.3	31–35	33.1
Sixth	42–48	44.7	38–44	41.3
Seventh	..	..	48–55	41.3
Adult	55–67	60.5	66–75	70.8

The nymphs, when newly hatched, are always a deep green, but the colour lightens in the second instar; there is usually little or no subsequent change in colour of the other nymphal stages, although it becomes somewhat lighter in tint before moulting. There is a brown variant not uncommonly found but it is not usually abundant; this usually has a plum coloured tinge, the full brown colour not being assumed until the adult stage is reached. Brown and green nymphs may emerge from the one batch of eggs.

Immediately after moulting, the nymph is definitely macrocephalic (head larger than the remainder of the body), and the body tapers down to the pointed telson; as the instar develops, the abdomen increases until just before the moult, when the head is microcephalic. The abdomen is swollen as far as the penultimate segment, which is to be expected, for the last segment bears all the external genetalis in the male, and most of them in the female, and these change in size only at moulting.

The size of the various instars, taken from a large series of measurements, is given in the following table, the measurements being in millimetres:—

Instar.	Males.	Females.
1st	10–17	10–17
2nd	16–20	17–21
3rd	21–26	22–26
4th	25–31	24–30
5th	31–39	35–38
6th	38–46	36–45
		45–53

In insectaries in Rabaul, it was observed over a period of three years that within two weeks of the dry season setting in, all first to fourth instar nymphs on the palms were killed, even although the foliage was sprayed with water.

Experiments were carried out in breeding cages to ascertain the rate of feeding of the nymphs; difficulty was experienced in keeping alive the first four instars in these trials, but figures were obtained for some of the others. Sixth instar males and seventh females, in lots of mixed sexes, ate approximately 3.3 square inches of leaf surface per individual in 24 hours; batches in which female nymphs predominated averaged 3.9 square inches, while with males predominating the amounts consumed were about the same as the first figure given.

Just before moulting, the food consumption is very much reduced, and may even cease for three days, and always for 36 hours before the moult takes place.

In tests on longevity of nymphs without food, it was found that first instar nymphs will live under such conditions for seven days, although some will be dead at the end of four days. Nymphs of the last two stages will live under such conditions for seven days, although some will be dead at the end of four days. Nymphs of the last two stages will live as long as seven days, unless they are almost ready to moult. Under such conditions they will survive longer; one specimen lived for twelve days, when it transformed into the next instar.

There is a heavy mortality in the early instars, especially in the first, which may be aggravated in the later stages of an infestation when all the older foliage has been eaten and only fronds are available. If first and second instar "hoppers" are fed on young leaves, the fuzz along the edges of the leaf apparently clogs the mandibles, and the insects will be observed attempting to clean the mouth parts with the tarsal claws. It is regularly found that if old and young foliage are put in the same cage together with *Sexava* at any stage of development of *Sexava*, that the old foliage will be consumed first, and the young left entirely, or almost entirely, untouched.

From the information already given, it is evident that the life-cycle is a long one, and may be summarized as follows:—

	Days
Egg period	49–107
Nymphal period, male	78–117
Nymphal period, female	90–124

This gives a full cycle for males of 127–224 days, and for females 168–241 days, or 18–32 weeks in the former and 24–34 weeks in the latter.

ADULTS.

The adult insect is, in most cases, rich green in colour with the distal margins of the wings and elytra brownish; when the wings are folded this marking forms a medium brown line along the back. Otherwise there are no prominent markings. A brown variation in colouration is not uncommonly met with, but is not usually abundant; in these cases the colour is a light chocolate brown, with no markings. These remarks hold good for the species occurring in all districts except New Hanover; most of the "hoppers" in this locality are brown in colour with the elytra marked with darker markings in an irregular pattern, while the inside of the femur of the hind legs is almost black.

The following measurements are an average of a large series:—

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	mm.
Body length, male ..	48–57
Body length, female ..	57–63
Head to tip of distal extremity of folded wings, male ..	74–83
Head to tip of distal extremity of folded wings, female ..	86–92
Antennae, longest ..	209
Antennae, average ..	204
Ovipositor ..	31–33

Emergence of the adult usually occurs at night, the cast skin being consumed by the insect shortly after emergence is completed.

Copulation has been observed in the field shortly before sundown, but is probably most common at night. In breeding cages, females have been observed with the spermatophore attached to the genitalia as early as 5 p.m.; this has also been noticed in the case of females collected in the field between 8 and 9 a.m., but in such cases copulation could have taken place the previous night.

When about to copulate, the male ranges alongside the female, facing in the same direction, depresses the abdomen and passes it underneath that of the female. When the genitalia of both sexes are in juxtaposition, the male extrudes a gelatinous blob containing the semen (the spermatophore), and fastens it to the genitalia of the female, where it remains for a considerable time, probably 12 to 24 hours. The whole act of copulation occupies only a few seconds.

From observations made in the adults bred in captivity and kept in field breeding cages, the period from emergence of adult to copulation has been 10–12 days, while the period from copulation to first oviposition has been 21–31 days. Adults kept in these cages have given a length of life of 35–110 days (average 72.3) for males, and 28–91 days (average 67.1) for females.

The number of eggs laid by a single female in captivity has averaged 40, although as many as 52 have been counted.

Although oviposition continues throughout practically the whole lifetime of the female, the rate is greater in the earlier than in the later portion. Mating has been observed to take place a number of times during the life of the female, so that it would appear that more than one mating is required for the fertilization of successive batches of eggs.

The period covered by a complete generation, i.e., from deposition of egg to deposition of egg by the female of that generation, averages 212 days, made up as follows:—

	Days.
Egg period	78
Hatching to adult	101
Adult to oviposition	33

In night collection of "hoppers" in the plantation, it has been found from counts made of adults coming down the trunks of the palms that the percentage of females is very much greater than that of the males. This movement is, however, very largely influenced by the local climatic conditions. The number collected is always greatest on dark cloudy nights after rain, especially when the rain has fallen late in the afternoon, and is least on bright clear nights after a dry day, or on bright moonlight nights. A long series of counts has given the following percentages for males and females collected at night: males 14 (range 4–31), females 86 (range 69–96).

The proportion of the sexes has been difficult to obtain. From collections made by natives from palms in the plantation over a period of six months, the figures were males 55 per cent. and females 45 per cent. On the other hand, in conjunction with insecticidal dusting trials (*see* "Control Measures"), the *Sexava* population of a large number of palms was counted by cutting off the fronds of selected palms, lowering the fronds carefully to the ground, and there counting the number of adult and nymphal forms present in the foliage. A watch was kept for any "hoppers" that might have left the frond when being cut or lowered, any such being collected and added to the count. The proportion of the sexes of adult *Sexava* determined in this way was an average of 70 per cent. male and 30 per cent. females. On the other hand, in the counts of the nymphal forms in the above cases, the proportion of sexes was 49.5 per cent. males and 50.5 per cent. females.

In field cages with ample food, the longevity of male adults was 35 to 110 days (average 82.8), and of female adults 28 to 91 days (average 67.1). Without food the adults lived 3½ days.

The adults and nymphs require water in addition to the moisture contained in the foliage, as shown by the fact that when kept in captivity and the foliage sprayed with water, all stages were noted sucking up the droplets of water.

The powers of flight of the adults are very poor, wings used more to volplane from the head of the palms to the ground. When disturbed, they may fly from one palm to the next, but this is practically the limit of flight, and even then loss of elevation is noted. In trying to take off from the ground, it is always noted that they can only rise 2 to 3 feet and, after covering a distance of about 30 feet, they fall back again, alighting on the grass, &c.

Stridulation is not apparently entirely a sex call and although particularly strong at night, it may be heard during the day, especially when the pest population is large. Migration from one centre to another is only likely to take place when coco-nut foliage on which *Sexava* nymphs or adults are present is carried about. Fronds carried around on native canoes have been observed to carry *Sexava* in this manner, and the pest may be thus dispersed over appreciable distances.

Within the confines of a plantation movement of adults and nymphs may take place from palm to palm where fronds of adjacent palms are overlapping, or by adults descending at night from one palm and re-ascending another further away. But as it has been noted that dispersion is so slow, any such movement is probably governed more by food supply than any other factor.

Feeding mostly takes place after dark, but on dull, cloudy or rainy days, feeding may occur also during the day.

Tests have been carried out in field breeding cages to try and ascertain the quantity of leaf eaten per diem per insect; in all these tests mature coco-nut foliage was used for feeding the insects, and fresh leaves were added once or twice every 24 hours. Under these conditions, the average consumption of the adult "hoppers" per 24 hours per insect was 3 to 4 square inches of leaf tissue, i.e., about the same as for the final nymphal instars.

Although coco-nut foliage is the preferred food of *Sexava*, other plants on which the insects have been observed to feed in the field are Sago palm (*Metroxlyn sagu*), Banana (*Musa* spp.), *Pandanus* spp., Betel nut (*Areca catechu*), *Heliconia* spp., *Ravenala* spp., Nipa palm (*Nipa fruticans*). In cages the foliage of *Pennisetum macrostacium* ("karapai" in pidgin) has been fed on freely by *Sexava*.

CONTROL MEASURES.

Mechanical measures, when efficiently carried out in the initial stages of an infestation, will give a satisfactory control of the pest, but where the value per acre of the agricultural product is relatively low, costs must necessarily be closely studied, and if there is an alternative scheme of attack requiring less expenditure, such as biological measures (i.e. the utilization of parasites), it is worthy of the fullest study. Particular attention was paid to this line of research from the very beginning of the work on the *Sexava* problem.

The search for indigenous parasites resulted in finding the egg parasites, *Doirania leefmansi*, Waterst. on New Hanover in 1930. In 1932, a species of *Encyrtidae* and a species of *Trichogrammatidae*, later identified as *Leefmansia bicolor*, Waterst. var. and *Doirania leefmansi*, Waterst. were bred from *Sexava* eggs in Manus; these were apparently rare as they were only bred on a single occasion with each species. Further breeding in the Manus District showed two species of *Scelionidae*, *Prosapegus atrellus*, Dodd. and *Scelio* sp., and *Ootetrastichus dubius*, Waterst. (fam. *Eulophidae*) to be present, but only in very small numbers.

On New Hanover, the following species were later bred from *Sexava* eggs, *Doirania leefmansi*, Waterst., *Leefmansia bicolor*, Waterst. var. and a species of *Mymaridae* (genus near *Anaphes*), all occurring in appreciable numbers, and also *Prosapegus atrellus*, Dodd. and *Ootetrastichus dubius*, Waterst. occurring to a much lesser extent.

Eulophid

In the Arawe District of New Britain, *Prosapegus atrellus*, Dodd. and *Ootetrastichus dubius*, Waterst. were bred from *Sexava* eggs collected locally; the latter species was noted to be more plentiful in this area than elsewhere in the Territory.

On New Ireland, *P. atrellus*, Dodd. and a small species of *Mymaridae*, distinct from that bred in Manus and New Hanover, have been bred from this host, while on Lihir Island, off the east coast of New Ireland, *P. atrellus* and a species of *Eulophidae* were fairly numerous in two lots of *Sexava* eggs sent in.

From both the Rabaul and Talasea sections of New Britain, a species of *Eulophidae,* apparently identical with that from Lihir Island, has been bred on several occasions.

Of the species of parasites indigenous to the Territory of New Guinea, *D. leefmansi, Leefmansia bicolor,* the *Mymarid* from New Hanover and possibly the species of *Eulophidae* from Lihir Island have been found in sufficient numbers and of such frequency as to warrant closer study to determine their possible economic importance, and in the course of the research work, especially on New Hanover, the first three species received particular attention.

Cf. XXVI, 135

All the parasites mentioned belong to the *Hymenoptera,* a group of insects which are popularly known as "wasps", but as the general idea of what constitutes a "wasp" is that of a relatively large insect, a brief note on each of these useful insects may perhaps give the layman a more accurate appreciation of the size of such parasitic wasps.

Doirania leefmansi. Waterst. is approximately half a millimetre* in length, which to the naked eye appears as a minute dark speck: when examined with a magnifying glass it is seen to have a light-coloured thorax and a dark abdomen.

Leefmansia bicolor. Waterst. measures approximately one and a half millimetres in length, and has a reddish thorax and dark abdomen.

Mymaridae sp. (genus near *Anaphes*) measures approximately one-third of a millimetre in length, and is generally dark in colour. An interesting feature with this species is that the males are quite distinct in appearance to the females, being much more robust and wingless and with antennae of thirteen segments. The males emerge on to the surface of the host eggs, and copulate with the females as they emerge: they do not move away from the egg, and die in not more than half an hour.

Ootetrastichus dubius, Waterst. is a black insect with light-coloured legs; it measures approximately one and a half millimetres in length.

Prosapegus atrellus, Dodd. is a dark-coloured insect with reddish-brown legs; it measures approximately seven and a half millimetres in length.

All the other species referred to are less than one millimetre in length.

In the course of the research work carried out on New Hanover during July and August, 1934, a large series of dissections were made of Sexava eggs collected in: (i) the soil; (ii) the fibre in the head of the palms; and (iii) the epiphytic growths on the trunks of the palms to ascertain the relative percentage of parasitism of the indigenous parasites; the results are given in the following table:—

Sexava eggs coll. in—	Percentage of Parasitism by—					Total.
	D. leefmansi.	*L. bicolor* var.	*Mymarid* sp.	*P. atrellus.*	*O. dubius.*	
Soil	6.7	2.3	4.7	Nil	Trace	13.7
Fibre, head of palm ..	11.7	4.4	5.2	Nil	Nil	21.3
Epiphytes	16.3	6.0	3.7	.1	Nil	26.1

On only one occasion were two species found together in the one *Sexava* egg, *D. leefmansi* and *L. bicolor* larvae occurring together; it is indicated, therefore, that parasite interference did not occur between the various species.

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* Note.—25 millimetres = 1 inch.

Where . — in New Hanover

The life-cycle was worked out for four species, as below:—

D. leefmansi	39–41 days (av. 39.8)
L. bicolor var.	31–35 days (av. 33.0)
O. dubius	30–36 days (av. 33.1)
Mymarid sp.	23–25 days (av. 27.8)

With the exception of *L. bicolor*, great difficulty was experienced in breeding these parasites in the field laboratory, regulation of moisture in the breeding tubes being the main cause. XXIV, Sol -

Parasites Recorded in the Netherlands East Indies.

In 1927, Dr. Leefmans recorded *Doirania leefmansi,* Waterst., *Leefmansia bicolor,* Waterst. and *Ootetrastichus dubius,* Waterst. as parasites of eggs of *Sexava nubila,* St. in Amboina.

In 1930, Dr. Reyne recorded *Prosapegus atrellus,* Dodd. and *Ootetrastichus dubius,* Waterst. as parasites of *Sexava* eggs along the coast of Dutch New Guinea; *Ootetrastichus dubius,* Waterst. from Halmahera; and *Doirania leefmansi,* Waterst. from the Banngai Islands.

D. leefmansi and *L. bicolor* were reported by Dr. Leefmans as being of economic importance as parasites of *Sexava* and, as previously stated, a small colony of the former species and a strong colony of the latter species were bred in Amboina by the Senior Author, and successfully brought to this Territory in April, 1933. Particular attention was paid to *L. bicolor* owing to the ease with which it could be bred in the laboratory, and this was commenced immediately to build up stocks for liberation in the plantations, and for distribution to other parts of the Territory. A study was also made of the binomics of the parasite under local conditions, these in most centres being markedly different from those in Amboina.

LEEFMANSIA BICOLOR.

The average life-cycle of this parasite in the field laboratory in Manus was 26 days, with a range of 24-29 days. On New Hanover, however, where the night temperatures especially were lower than in Manus, the cycle averaged 28.8 days with a range of 26-31 days.

From *Sexava* eggs parasitized in Amboina, parasites emerged in 28-29 days; this may have been influenced by the varying temperatures and the vibrations on the schooner experienced in the fourteen days' trip from Amboina to Manus.

The age of the host egg has a marked effect on the life-cycle of the parasites, as shown by the following figures of observations made in the field laboratory in Manus:—

Age of host egg in days.	Duration of life-cycle.	
	Minimum.	Maximum.
2– 3	37	49
4– 6	30	35
7–10	35	38
11–14	29	36
16–21	20	27
22–27	18	26
28–37	20	27
38–44	20	26

It is, therefore, evident that the life-cycle of the parasites is considerably prolonged when host eggs of under sixteen days old are placed in the submission jars with the parasites. Apart from the lengthening of the life-cycle, this factor does not appear to have any influence on the number of parasites emerging, their size, virility, &c.

The average longevity with feeding of the adult parasites is seven days, although some have lived for as long as fourteen days; males apparently live longer than females.

Copulation takes place within a few minutes of emergence, and continues throughout life, and oviposition commences soon after copulation. The duration of active parasitism covers several days.

Both sexes are markedly phytotropic (i.e., attracted to light), although this appears to vary according to the container in which they are confined; from a narrow tube they will move towards the light much faster than from a wide tube or a bottle. This habit can be utilized in transferring the parasites from one jar to another or into tubes for liberation of adults.

In laboratory breeding of these parasites, glass preserving jars of two-quart capacity were used for submission of the host eggs to wasps, the eggs forming a thin layer over one side of the jar lying side down; slightly diluted honey was used for food for the live insects.

The total percentage of *Sexava* eggs parasitized in the laboratory averaged 82.4 with a range of 73.7 to 91.6, of which an average of 64.5 per cent. yielded live parasites.

The average number of parasites per host egg was twenty.

In order to test the practicability of emergence of the parasites through the soil, parasitized *Sexava* eggs were buried in loose soil at various depths, and examined periodically; tanglefoot paper was placed on the surface around the sites of burial. It was found that the adults of *L. bicolor* could reach the surface through 1½ inches of loose soil. (But 3/4 in in XXIV, 202)

Liberation of parasites in the field in bulk lots of host eggs was carried out by placing the eggs in small wire-gauze cages which were suspended by wire from a stake, or the fronds of young palms, in the plantation. Observations made over a long period have shown that the emergence of wasps from these field cages was much heavier than from control lots held in jars in the laboratory.

With continued liberation from laboratory stocks, *L. bicolor* became established in the field fairly readily and rapidly; in most cases, however, it failed to maintain itself after liberation from stocks had ceased. In one case of native groves in the Arawe area, this species was recovered in fair numbers, and in small numbers from a plantation in the same area three years after liberations stopped; on New Hanover this parasite has maintained itself satisfactorily for several years. It may be stated that the latter centre more closely approximates to the field conditions existing in Amboina than most other parts of the Territory where this parasite has been liberated.

With the idea of increasing the number of species of parasites liberated, and on account of the difficulty experienced in the laboratory breeding of *D. leefmansi* and the *Mymarid* sp. on New Hanover, bulk lots of *Sexava* eggs have been collected from time to time from that area, and mixed lots of them have been distributed to other centres of *Sexava* occurrence. The reason for mixing host eggs in this way was that when the junior author was stationed on New Hanover

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he found that the distribution of the various parasites mentioned was not regular, but that one species would be more prevalent in one or more centres than any of the others; mixing thus gives a better chance for all species to be represented in any lot of host eggs sent out.

Mechanical Measures.

In conjunction with the parasite breeding work, attention was given to other lines of attack on the problem, in order that if one line failed another could be taken up, or a combined scheme of two or more lines might be undertaken to obtain the required result.

Large numbers of adults and nymphs can be collected and destroyed by stacking the old coco-nut fronds along the rows of palms through an infested area, and lighting them from the outside rows inwards to the centre; the heat will cause most of the "hoppers" to lose their hold in the palms, and fall to the ground, as the adults have very poor powers of flight.

Collection of eggs systematically through an infested area will lead to the destruction of many potential "hoppers". Turning over the soil with hoes, or by ploughing where this is possible, so as to bury the eggs below the surface, will prevent large numbers of nymphs reaching the surface; ants, lizards, &c., will attack eggs exposed on the top of the soil during such operations.

The habit, of female adults in particular, of coming down to the ground at night to lay can be made great use of in night collections from about 7 to 9 p.m. It is possible that the use of flame-throwers or even flares made from dry fronds would obviate the hand collection of the "hoppers" without causing material damage to the trunks of the palms.

In cases of a very localized infestation, such as occurs in the initial stages of *Sexava* plague occurrence, "tanglefoot" bands may have an economic value in preventing considerable numbers of first instar nymphs from reaching the crown of the palms. Several series of tests have been carried out with two types of "tree tanglefoot", one with a resin base and the other with a wax base; the latter was quite unsuitable for the purposes required. Although the tackiness is greater when the bands are fresh, this can be "rubbed up" at intervals to break any film on the surface. Such bands made with the resin base material have remained actively tacky for two and a half months, but the initial precaution must be taken of removing any moss or other plant growth from the palm trunk before applying the "tanglefoot". The most satisfactory type of band found in the field trials was 3½ to 4 inches wide and was put on with the hand; where a piece of wood was used, the band was often too thin to last.

Tests were made with these bands to which different poisons had been added, and it was found that nymphs crossing a band of "tanglefoot" to which 10 per cent. of sodium arsenate was added showed 100 per cent. mortality in from 7 to 39 hours. With 10 per cent. mercuric chloride, all the nymphs were paralysed within five hours, and of twelve nymphs used, five were dead in 24 hours, one more in 48 hours; three lived for 72 hours and one for 96 hours, which is approximately the longest period nymphs can live without food. With sodium fluoride, there was 25 per cent. mortality in 24 hours, and 65 per cent. in 48 hours, while all were dead in 72 hours. Paris green gave a mortality of 35 per cent. in 24 hours and 50 per cent. in 48 hours,

2; xvii, 495; xxvii, 277.

An attempt was made to kill the "hoppers" by means of the standard locust bait, composed of Paris green, bran, sodium arsenate, molasses and lemons; this was scattered both in the head of the palms and around the base on the ground, but there was no evidence to show that the insects fed on it at all. XXiv, 202.

Insecticides Applied to the Palms.

In order to test out the use of insecticides applied to the coco-nut palm foliage, small coco-nut palms were sprayed with arsenate of lead at the usual strength, and the leaves placed in observation cages with adult and nymphal *Sexava*. It was found that feeding ceased after the first night and 100 per cent. were dead within three days. This proved to be toxic eight days after spraying, even although 147 points of rain had fallen in the interim.

Spraying of coco-nut palms on a plantation presents the great difficulty of obtaining an adequate supply of soft water; even in cases where water is available, the cartage would generally be an appreciable cost. Owing to the height of the palm, a high-powered spray plant would be required with some means of traction, which would be expensive.

The application of the insecticide as a dry dust obviates the need of water, and the plant required is much lower in cost than a spraying outfit for the same purpose.

A dusting machine powered with a 6 h.p. petrol engine was purchased by the administration, and tests were first made in the laboratory in wire-gauze cages to determine the most suitable insecticide for field trials.

The dusts experimented with comprised various proprietary preparations and also straight dusts with arsenate of lead, calcium arsenate, Paris green and derris as the toxic constituents.

The cages used were made of copra-bed wire and were 3 feet high and 2 feet in diameter: coco-nut leaves were suspended in the cages with the "hoppers" and dusted. Fresh foliage was added after one night's feeding, and the relative toxicity of the dust was reckoned in the number of "hoppers" killed in three days.

Derris dusts were very irregular in results—a dust which would give a high degree of mortality on one occasion would give a very poor result on another. The arsenicals, on the other hand, gave a consistently high mortality. Paris green was found, in later trials, to scald the foliage, and was, therefore, eliminated from the trials. Both arsenate of lead and calcium arsenate gave highly satisfactory results in field trials, but the latter appeared to possess one advantage, that it had a delayed action in killing the "hoppers" that was not found with the former. One brand showed itself superior in power of adhesion to the leaf.

From the results obtained, it is evident that dusting would require to be done twice, with an interval of about three months between treatments, in order to obtain effective control.

Owing to the very smooth surface of the leaf of the coco-nut palm, adhesion of most dusts is poor, although there is a definite layer left on the upper surface of the leaves. In an endeavour to improve the adhesion of the dust, various fillers were tested, mostly of a "kaolin clay" nature; one proprietary preparation of this type showed particular promise, especially when dusted over foliage on which the night dew was still present.

In later field trials, it was found to be possible to dust two rows of palms together with satisfactory results; this naturally presents a considerable saving in time and material.

From the field trials, it is definitely proved that calcium arsenate dust will kill practically 100 per cent. of the *Sexava* in the palms provided that there is 24 or preferably 48 hours without rain after application of the insecticide.

Other Natural Enemies.

Crows (*Corvus orru*), white-headed hawk (*Accipiter* sp.), "Willie Wagtail" (*Rhipidura tricolor*), Kingfisher (*Halcyon sanctus*) and various lizards have been observed feeding on *Sexava* on the palms. During a normal condition of low pest population these natural enemies probably assist in destroying a number of "hopper" nymphs and adults, but they are nowhere in sufficient numbers to be of any material benefit during heavy infestation.

"Guinea fowls" (*Numidia meleagris*) were introduced into one plantation as, owing to their insectivorous habits, it was thought they would assist in the control of *Sexava* by killing numbers of the "hoppers". The birds were under continuous observation for several months. They proved a complete failure as pest destroyers on account of their habits of rarely straying far from the bungalow, going to roost well before sundown, and not leaving their roost until well after sunrise. For these reasons they were not even as useful as domestic fowls.

Not in the Review.

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HOW TO MAKE SOAP.

Ingredients.—6 lb. clean dripping, 2 gallons water, 1 lb. caustic soda, ½ lb. resin and 3 tablespoons kerosene.

Method.—Put dripping, resin and water into a kerosene tin and boil for 15 to 30 minutes until all the fat is melted. Add kerosene and remove from the fire. Next gradually add caustic soda direct from the tin, allowing bubbles to subside between each addition. Boil gently for one or two hours and then pour into a box lined with a damp cloth. When solid, cut into bars and store in a dry place till hardened.

THE FOOD VALUE OF THE COCO-NUT.*

(*By Reginald Child.*)

The human or other animal requirements for satisfactory growth are air (oxygen), water and food and the food consumed must contain the following factors:—

(*a*) The major food constituents—protein, fat and carbohydrate.

(*b*) Certain mineral salts.

(*c*) Certain accessory food factors, known as vitamins.

It is the purpose of the present short article to discuss what of these essential factors the coco-nut can contribute to the diet. The products concerned are the kernel (and water) of the nut itself, and coco-nut toddy.

Coco-nut Kernel.

The kernel of the coco-nut contains all three of the major constituents: protein, fat and carbohydrate, though, as will be seen, it is not an equally good source of all of them.

In its fresh state as "wet meat", the kernel contains a good deal of moisture, which may be reckoned to average about 45 per cent. The percentage contents of other constituents are shown in column 1 of Table I., from which it will be seen that the principal constituent is oil or fat.

Freshly scraped coco-nut meat is commonly used in Ceylon as an addition to curries and in other ways in the diet. It does not keep well, since it is readily attacked by moulds and bacteria; it is very difficult to preserve.

Since wet meat so easily goes bad, commercially it is dried to a content of about 6 per cent. of moisture, at which stage it keeps reasonably well. The product is, of course, the familiar copra. When the kernel is thus dried, i.e. moisture content reduced from about 48 per cent. to 6 per cent., the percentages of the other constituents are proportionately increased, and an average sample of Ceylon copra has the composition shown in column 2 of Table I.

Copra.

The very best white copra is consumed as food in parts of India, the demand for edible copra having somewhat increased of late years. But by far the largest proportion of commercial copra is used for the production of coco-nut oil.

As the Table I. shows, copra contains about 68 per cent. of oil (dry weight). Modern presses extract about 62–63 per cent. of oil, the balance oil being left in the poonac.

Poonac.

The residue is coco-nut cake or "poonac". This has the composition shown in column 3 of Table I. Poonac is a valuable protein concentrate for dairy cows and fattening cattle.

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* Extract from an article published in *Young Ceylon*, July–August, 1939.

By a patented process, it has been found possible to extract the protein in a pure form, which may have application for special purposes in animal and human nutrition. By a similar process it is possible to extract part of the carbohydrates, so that the three major food constituents of coco-nut kernel can be clearly summarized, and this is done in Table III. after the discussion of other products.

TABLE I.

Constituent.	1 Fresh Coco-nut Kernel (Typical sample).	2 Number 1 Copra (Average sample).	3 Poonac or Press Cake (Average sample).
	Per cent.	Per cent.	Per cent.
Moisture	48.0	6.8	9.8
Oil	35.5	63.7	8.1
Protein	4.3	7.6	21.0
Crude Fibre	2.1	3.8	10.5
Ash (Mineral constituents)	1.1	2.0	5.5
Nitrogen-free extract (Carbohydrates, &c.)	9.0	16.1	45.1

Desiccated Coco-nut.

The wet meat is also dried in another process to produce desiccated coco-nut for human consumption. The brown parings or skin is removed in this case and the drying is more severe, good desiccated coco-nut when fresh containing 1 to 2 per cent. of moisture.

Desiccated coco-nut has about the same composition as copra, except for this lower moisture content. Since also the parings contain less oil than the rest of the nut, the oil content of the desiccated coco-nut is slightly higher than that of copra and may be between 70 and 72 per cent.

Coco-nut Flour.

When desiccated coco-nut is pressed there is obtained about 65 per cent. of pure white oil. The residue which corresponds to poonac from copra, can be ground and forms a coco-nut flour, which has been put on the market. The following table shows its composition in comparison with wheat flour:—

TABLE II.

Constituent.	Wheat Flour.		Coco-nut Flour (Typical sample).
	Minimum.	Maximum.	
Moisture	9.0	15.0	5.7
Ether extract (fat) ..	0.5	2.0	7.2
Protein (Nx 6.25) ..	8.0	15.0 (Av. 12.0)	20.4
Ash	0.3	0.8	5.4
Fibre	0.1	1.0	9.2

As will be seen, its composition resembles that of poonac.

Parings.

It is not necessary to say much in this article about parings. The dry parings are pressed to give parings oil, which differs slightly in composition from ordinary coco-nut oil and is mostly used for soap making.

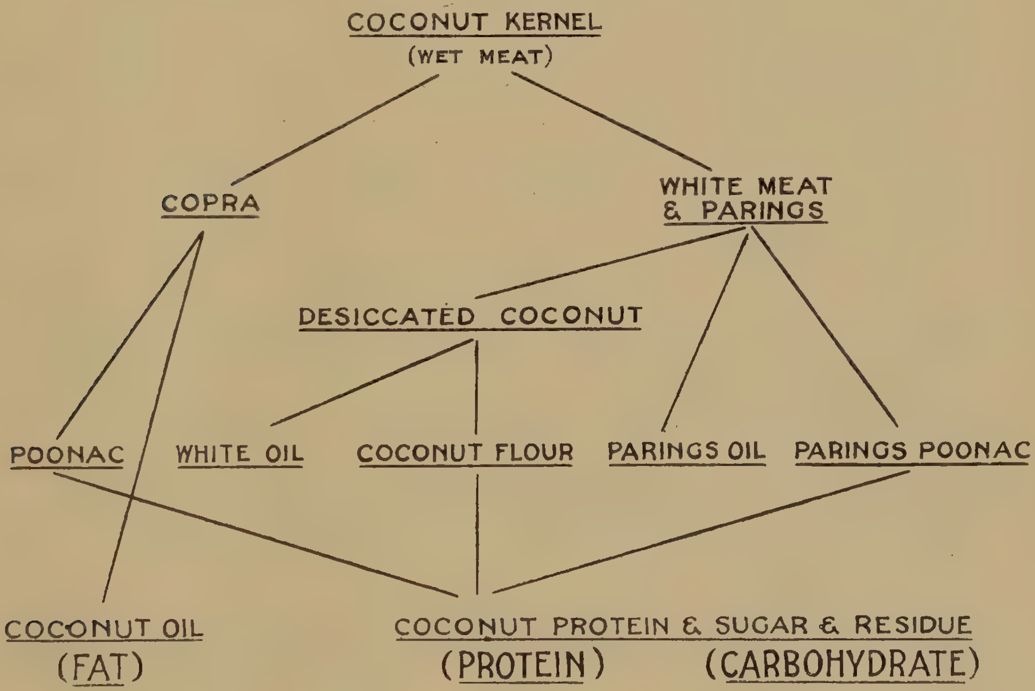
The parings poonac has about the same composition as ordinary poonac, but there is some evidence that its vitamin content is higher and it is now largely preferred in Ceylon for cattle feeding.

Coco-nut Oil.

The coco-nut's highest contribution to animal and human nutrition is oil or fat. It is not the intention of this article to give highly technical details, but it must be mentioned here that coco-nut oil has been found to be the most readily digested of all the edible fats in general use in the world, and it is likely that margarine made from this oil is more readily digested even than butter.

Summary of products of coco-nut kernel. The foregoing may be summarized in tabular form—

TABLE III.


COCONUT KERNEL
(WET MEAT)
COPRA
WHITE MEAT
& PARINGS
DESICCATED COCONUT
POONAC
WHITE OIL
COCONUT FLOUR
PARINGS OIL
PARINGS POONAC
COCONUT OIL
(FAT)
COCONUT PROTEIN & SUGAR & RESIDUE
(PROTEIN)
(CARBOHYDRATE)

Coco-nut Protein.

Protein is not a single chemical substance. Proteins from various sources vary considerably in their ultimate composition, animal protein being usually of a different type from plant protein. Certain proteins even if consumed in large quantities are not capable of supporting an animal in health, and in general it may be said that a mixed diet is likely to be better than a single source of protein.

The biologist distinguishes between "good" and "poor" protein. Unlike a number of plant proteins (such as those of maize and barley), that of the coco-nut is fairly satisfactory, and work in America in 1919 and onwards has shown that the globulin (a protein form) of the coco-nut produces normal growth when used as the sole source of protein in an otherwise complete diet. In connexion with animal feeding it was found that poonac furnishes the necessary protein for growth at almost a normal rate.

Carbohydrates.

The carbohydrates in coco-nut kernel have not been so carefully studied as the other constituents. It may be said that at least 7 per cent. of ordinary sugar is present in the fresh dried kernel (copra or desiccated coco-nut). The bulk of the carbohydrate is in the form of cellulose and much of this is digestible.

Coco-nut Milk.

Before leaving the subject of coco-nut kernel, reference must be made to the emulsion obtained by pressing the grated substance known as coco-nut milk so commonly used in Ceylon households. This contains a good deal of the constituents of the kernel without so much of the indigestible fibre. A recent analysis gave the following results:—

	Per cent.
Water	52
Oil	27
Carbohydrate	15.9
Protein	4
Mineral substances	1.1

Suggestions have been made that coco-nut milk and similar preparations from the young nut might be a substitute for cow's milk. It would not, however, be entirely satisfactory as a milk substitute, owing to its deficiency in certain mineral salts and vitamins.

Mineral Salts.

The principal mineral constituent of coco-nut products is potash. But this is only one and not the most important of mineral salts required for maintenance of growth and health. From the Ceylon point of view, calcium (lime) is probably the most important and coco-nut milk and other products do not contain notable quantities of lime.

Vitamins.

It must be emphasized that vitamins are not energy-providing food constituents such as fat, protein and carbohydrate. They are compounds required in very minute quantities and their action may be roughly compared to the lubricating oil used on an engine in comparison with the fuel oil which corresponds to the major food constituents.

On the whole, the coco-nut is not regarded as a good source of vitamin. Reference has already been made to the possible presence of water-soluble vitamins in poonac. Fat soluble vitamins A and E, but not D, have been reported in coco-nut kernel and oil but none of these is present in sufficient quantities. Vitamin C seems to be absent from the kernel, but is present in the young nut water (Kurumba), and particularly in fresh toddy.

Coco-nut Toddy.

Toddy is a good source of vitamin C and the B vitamins are also derived from toddy yeasts. As its major constituent, sweet toddy contains about 16 per cent. of sugar (carbohydrate).

BREAD-MAKING.*

(*By Margaret A. Wylie.*)

The science of bread-making involves some knowledge of both chemistry and physics. A complete study of this art, therefore, necessitates familiarity with some of the fundamental principles of these sciences. Though bread has been made for countless ages, and is the staple food of man, its successful making has been really the result of knowledge gained empirically. Modern hygiene has, however, demanded a more definite basis to justify its continuance as the main part of human diet.

Flour.—Of all cereals, wheat yields the best flour for bread. This is due to the fact that it is the only grain which contains the constituent gluten in the proportion and of the desired quality essential for turning out light, spongy bread. Flour also contains a large proportion of starch. The following is a simple test of their presence:—A cupful of white flour in a muslin bag, if saturated with water and pressed, leaves a yellowish, tough, elastic substance in the bag, somewhat the size of a walnut. This is the gluten, the starch having been expelled. This experiment gives a rough estimate of the proportion of gluten to starch in a standard flour.

White flours are classified differently in different countries. There is the millers' classification, and the classification for commercial convenience in buying and selling, but the housewives' classification is from a very different standpoint, and should be as follows:—

(1) Strong or old flour.
(2) New flour.
(3) Fine flour.
(4) Weak or feeble bodied flour.

The first is of a deep, creamy colour, the kind that tumbles in a fluffy light manner out of a bag. If examined with a microscope, its gluten cell walls will be found to be very strong, having power to hold the gases that are formed by the action of yeast. Old flour is dry, and will absorb a large proportion of water.

The second type is whiter than the above and on account of its inherent dampness absorbs less water. It may be noticed that some flours retain their shape when pressed, an invariable sign that the flour is new.

The third, fine flour, is soft and elastic, not spongy and puffy, and produces a smaller loaf to the same proportion of flour. Its gluten is usually plentiful, its flavour in general being fine and "nutty".

Weak or feeble bodied flour is deficient in gluten, and hence in the capacity to retain the gases produced by the action of the yeast, as well in the power of absorbing moisture.

Strong flours therefore are most suitable for bread, fine flours for Christmas cakes, short pastes and short bread.

Yeast.—The article on jam making showed that various moulds and bacteria were the cause of decomposition and putrefaction of foods, and how the spores of moulds float about in the air. It must be remembered, however, that as well as harmful organisms, the air furnishes useful bacteria. Wine, vinegar and cheese are the result of these bacteria, properly employed.

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* From the *Journal of Agriculture*, Western Australia.

Yeast also enters this category. It is a minute plant of the "fungi" family, so small that 1,000,000 would cover only 1 cubic inch. Warmth and moisture speed its growth, its food being the sugar formed from starch. It thrives best at 78 deg. F. Its chief power is that of changing starch to sugar, and then converting the sugar into alcohol and carbonic acid gas. Provided the right food and conditions are given it, yeast propagates rapidly, at the rate of 1,000,000 an hour.

The gas generated by the action of the yeast is all-important in bread-making, for it is that which causes the sponge to rise, striving as it does to escape from its imprisonment in the gluten cells. It is possible to classify yeasts thus:—

(*a*) Liquid yeast.
(*b*) Distillers' yeast.
(*c*) German or compressed yeast.
(*d*) Dried yeast.
(*e*) A semi-dried form called putty yeast.

Liquid yeast is cultivated from a mixture of potatoes, sugar, water and hops.

Distillers' or brewers' yeast is a natural type, skimmed from fermented rye.

German or compressed yeast is bought in cakes, chiefly in England or the Continent of Europe. Unfortunately this often spoils in transit through the tropics.

The dried variety is made from hops and potatoes, mixed with starch and pressed into cakes.

The last type is built up in layers of semi-dried yeast.

Hops.—Hops act as an antiseptic, i.e., they help to destroy the power of certain bacteria and prevent thus the propagation of wild yeast. Consequently, it is advisable to use yeast made from hops, as the use of poor potatoes and impure materials produces wild yeasts which spoil bread. As well as this negative use, hops improve the flavour of the bread.

To ensure really successful bread the making of yeast should be attended with every care and cleanliness. An old bottle (used before) can be used, but the corks and fittings must be perfectly clean, as the entry of foreign germs tends to spoil the value of the true yeast and start different cultures.

Preparation of Yeast.

Hop Yeast.—1 large potato, 1 pint water, 1 tablespoon sugar, 1 tablespoon flour, 1 teaspoon hops.

Method—

(1) Boil potato, add hops while still boiling. Boil 20 minutes.
(2) Strain, cool slightly, add flour and sugar.
(3) Bottle and cork tightly.
(4) The yeast should work in a few hours in a bottle previously used for yeast, 24 hours in a new bottle.
(5) A fig or a raisin added will make it work more quickly.

Acid Yeast.—A medium sized potato, 1½ tablespoons sugar, ½ teaspoon citric or tartaric acid, 1 cup warm water, 2 teaspoons flour.

Method—

(1) Boil and smash potato, add other ingredients and sufficient water to keep mixture at cupful.
(2) Bottle and cork tightly.
(3) Keep in a warm place 12 hours in an old yeast bottle and 24 hours (at least) in a new bottle.

White Bread.

Small quantity.—1½ lb. flour, ¾ pint tepid water, 2 tablespoons home-made or 1 level tablespoon brewers' yeast, 2 teaspoons sugar, 1 teaspoon salt.

Method—

(1) Sift and warm 1 lb. flour, make a well in the centre.
(2) Beat yeast and sugar to a cream.
(3) Pour yeast and tepid water into flour and stir to a moist dough. Beat well.
(4) Cover and stand in a warm place till the dough doubles its size. (Brewers' yeast takes about one hour and home-made several hours.)
(5) Turn to a floured board and knead in the extra ½ lb. and salt until the dough is of even texture.
(6) Shape into loaves, put into greased and floured tins.
(7) Allow to rise in a warm place about half an hour.
(8) Cook in a hot oven until the loaf is well risen and brown, then place in a cooler part until the bread is cooked through—30 to 40 minutes in all.
(9) When cooked the bread should give a hollow sound when tapped on the bottom.

Wheaten Meal Bread.

1½ lb. whole or half wholemeal and half plain flour, 1 tablespoon yeast, 1 teaspoon salt, ¾ pint tepid water, 1 teaspoon sugar.

Method.—Proceed as for white bread, but more moisture, a hotter oven, and longer cooking is required.

The actual baking of bread is perhaps the most important part. With the utmost care in choosing flour, making yeast, and carrying out the correct procedure for mixing, if the oven is not at the right temperature the bread may be spoilt. The scientific baking of bread is to fix the air cells as quickly as possible by means of the hot oven. A novice would do well to test the oven thus:—Place a tablespoon of flour on a saucer for five minutes in the oven. If the oven is—

(*a*) Hot—the flour becomes dark brown.
(*b*) Moderate—the flour becomes a golden brown.
(*c*) Cool—the flour becomes pale brown.

The yeast will go on working or growing in the flour if the oven is too cool, still splitting up the starch and more alcohol is formed, which cannot escape. The bread thus has a "berry" taste. If, on the other hand, the oven is too hot and the loaf begins to brown in less than fifteen minutes, a crust is formed and the inside of the loaf remains damp and uncooked.

Abnormal Fermentation.—The normal fermentation in bread-making is due to the energy of the yeast plant growing and multiplying in the dough, giving off

CO_2 and producing changes which result in making bread palatable and digestible. Other fermentations, however, sometimes occur.

Sticky or sour bread is due to lactic acid bacteria. These are associated with low-grade flour. The germs of these bacteria often lie dormant until essentials, such as warmth and moisture, necessary to their growth, are provided and they can then develop. Injurious germs also appear with yeast. This is sometimes overcome by the use of hops, which assists true yeast to overpower poor yeast. Dirty utensils and troughs harbour injurious bacteria. All crevices and cracks are teeming with unseen life, which reproduce enormously when given favorable conditions.

Musty or mouldy bread is usually noticed only after bread has been cut. This is due to damp flour in which fungi or mould has developed. Bags, containers, &c., holding the flour should be thoroughly scalded and scoured before being used for a fresh supply.

The same procedure should be carried out if bread is what is termed " ropy ", or when tiny red marks appear. These, too, are the effects of wild yeasts, which have found their way into the dough.

METEOROLOGICAL NOTES.

(By R. J. McConnell, Department of Agriculture, Rabaul.)*

To the average planter and miner, as he fills in his monthly rainfall and climatic statistics, it probably seems that the whole business is useless and that the results of his observations only give rise to small-talk and to stock some Government archives. But to-day the weather bureau is an integral part of any successful community and although the observations of a single observer may have little value, the means of a large number of observations taken at selected points are of great value.

In temperate climates, where the weather is subject to sudden changes, bringing frost, heavy rain with hail, &c., ignorance of climatic statistics may spell ruin to the farmer. Many citrus and vegetable crops have been lost through farmers ignoring climatic predictions and being caught by cold spells.

In tropical agriculture it is essential to know the rainfall of a place before successful planting can be attempted and for crops which require protection, such as coffee and cacao, it is equally necessary to have information on prevailing winds and their comparative velocity.

New Guinea, with 8 major reporting stations and 103 minor reporting stations, is rapidly building up an efficient weather organization both for the benefit of the agriculturist and aircraft. The results of observations taken during 1939 at the Rabaul observatory in the Botanic Gardens are appended.

For comparative purposes, other meteorological data for Rabaul are to be found in the following issues of the *New Guinea Agricultural Gazette*:—

1936	Volume 2, Number 1, Page 31.
1937	Volume 3, Number 1, Page 27.
1938	Volume 4, Number 3, Page 23.
1938	Volume 4, Number 4, Page 58.
1939	Volume 5, Number 3, Page 8.

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* Relieving B. G. Challis—on leave.

GENERAL CLIMATOLOGICAL DATA.

Month.	Barometer mean for month, corrected to M.S.L. and standard gravity and temperature.	Amounts of clouds. Mean of 9 a.m. and 3 p.m. observation.	Number of clear days.	Highest barometer readings (corrected) 9 a.m. reading.	Date.	Lowest barometer readings (corrected) 3 p.m. reading.	Date.
January	29.755	6.5	16	29.850	18.1.39	29.663	27.1.39
February ..	29.773	7.1	7	29.895	19.2.39	29.647	3.2.39
March	29.764	7.5	5	29.827	30.3.39	29.651	6.3.39
April	29.778	6.5	9	29.887	1.4.39	29.680	15.4.39
May	29.796	5.1	14	29.906	10.5.39	29.680	19.5.39
June	29.815	5.9	13	29.925	18.6.39	29.686	29.6.39
July	29.831	4.3	15	29.950	24.7.39	29.740	3.7.39
August	29.765	5.6	15	29.890	31.8.39	29.649	18.8.39
September ..	29.837	5.8	18	29.969	7.9.39	29.710	18.9.39
October	29.812	6.9	14	29.912	3.10.39	29.703	30.10.39
November ..	29.771	6.3	14	29.863	16.11.39	29.658	30.11.39
December ..	29.801	5.9	14	29.893	27.12.39	29.697	3.12.39
Average ..	29.791	6.1	12.8	29.897	..	29.680	..
Extremes ..	29.837 September	7.5 March	18 September	29.969	7.9.39	29.647	3.2.39

TEMPERATURE.

Month.	Mean of the Maximum Thermometer Temperature.	Mean of the Minimum Thermometer Temperature.	Average Monthly Temperature.	Maximum Thermometer Highest Temperature, Reading.	Date.	Minimum Thermometer Lowest Temperature, Reading.	Date.	Mean of Thermometer Temperature on Grass.	Lowest Thermometer Temperature on Grass.	Date.
January ..	90.7	73.5	82.1	93.9	22.1.39	71.2	11.1.39	71.5	68.2	11.1.39
February ..	88.9	73.8	81.3	92.6	14.2.39	71.0	26.2.39	72.2	69.0	27.2.39
March	88.4	73.4	80.9	91.3	27.3.39	71.2	28.3.39	72.3	69.5	28.3.39
April	89.3	74.0	81.6	93.4	15.4.39	72.3	3.4.39	72.5	69.9	3.4.39
May	88.9	73.9	81.4	91.7	19.5.39	72.0	1.5.39	72.2	69.5	27.5.39
June	88.5	73.8	81.1	91.0	7.6.39	72.1	3.6.39	72.3	69.5	3.6.39
July	88.7	72.8	80.7	90.5	17.7.39	70.3	25.7.39	70.9	67.5	17.7.39
August	88.8	73.5	81.1	92.7	30.8.39	70.0	27.8.39	71.7	68.9	4.8.39
September ..	89.8	73.6	81.7	92.3	20.9.39	72.1	9.9.39	71.5	69.5	29.9.39
October	90.3	73.6	81.9	94.1	15.10.39	70.9	8.10.39	71.8	69.0	28.10.39
November ..	90.8	74.1	82.4	94.9	13.11.39	71.0	24.11.39	72.4	69.0	24.11.39
December ..	90.4	73.4	81.9	94.4	31.12.39	71.0	29.12.39	71.5	68.8	29.12.39
Average ..	89.5	73.6	81.5	92.7	..	71.3	..	71.9	69.1	..
Extremes ..	90.8 November	72.8 July	80.7 July	94.9	13.11.39	70.0	27.8.39	70.9 July	67.5	17.1.39

HUMIDITY AND RAINFALL.

Month.	Humidity.			Rainfall Monthly 1939.	Average Rainfall since 1914.	Greatest Monthly Rainfall.	Year.	Least Monthly Rainfall.	Year.	Wet Days Monthly 1939.	Wet Days Average since 1914.	Greatest Fall in 24 hours.	
	Mean 9 a.m.	Mean 3 p.m.	Mean of All Readings.									1939.	Date.
January ..	79.0	72.0	75.5	9.40	14.13	37.74	1916	4.77	1918	15.0	20.8	3.99	2.1.39
February ..	79.0	72.0	75.5	6.65	10.44	23.54	1923	3.38	1921	21.0	13.1	1.91	4.2.39
March	83.0	75.0	79.0	6.60	9.42	22.23	1919	3.91	1920	26.0	19.5	0.74	7.3.39
April	83.0	72.0	77.5	13.14	9.80	18.57	1925	0.93	1937	21.0	18.0	3.85	24.4.39
May	79.0	72.0	75.5	7.53	5.17	11.27	1930	0.74	1932	17.0	13.3	2.61	1.5.39
June	79.0	72.0	75.5	5.91	3.52	7.78	1923	0.79	1914	17.0	12.7	2.89	16.6.39
July	87.0	72.0	79.5	6.70	5.59	18.00	1930	0.09	1914	16.0	14.7	2.28	25.7.39
August ..	79.0	72.0	75.5	6.21	4.40	12.45	1937	0.36	1924	16.0	14.8	2.39	24.8.39
September ..	75.0	72.0	73.5	3.15	3.65	7.15	1921	0.32	1914	12.0	12.5	0.74	30.9.39
October ..	75.0	68.0	71.5	6.35	5.25	11.86	1928	0.62	1914	17.0	12.7	1.08	22.10.39
November ..	76.0	76.0	76.0	3.55	6.30	14.00	1921	1.73	1913	16.0	15.7	0.58	25.11.39
December ..	75.0	72.0	73.5	6.88	10.19	16.22	1919	3.66	1933	17.0	18.3	2.74	1.12.39
Average ..	79.1	72.3	75.7	6.84	7.32	..	..	..	..	17.6	15.5	2.15	..
Extremes ..	83.0	76.0	79.5	13.14 April	14.13 January	37.74 January	1916	0.09 July	1914	26.0 March	20.8 January	3.99 January	2.1.39

SURVEYING FOR AREA WITH A SURVEYOR'S STAFF.

In the last issue of the *Gazette* instructions for making and using a simple plantation level were given. In this issue the surveyor's staff will be similarly dealt with. This particular staff and the method of using it were first described by Alexander Gordon, of the University of the Philippines.

Construction.

A round block, 2 inches thick, was made. The block was sawed across the centre to about half an inch in depth, then resawed across the centre at right angles to the first cut. These cuts serve as sight lines. The block is set on a staff by means of a peg so that the block may turn about its centre. (*See* Figure 1.)

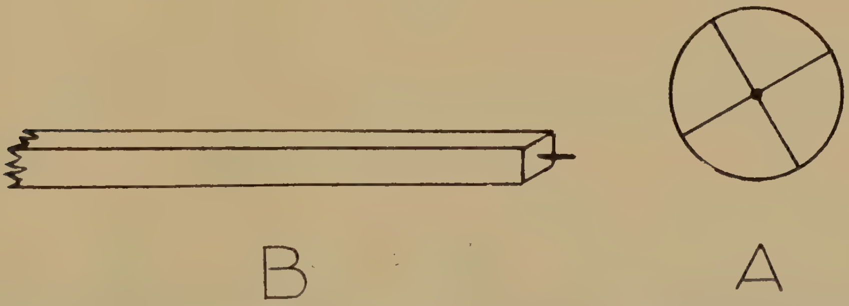


Figure 1.—The Surveyor's staff taken apart. (*a*) a wooden block; (*b*) wooden staff showing peg for block attachment. Note the saw cuts on block.

How to use a Surveyor's Staff.

Set-up.—The surveyor's staff is divided into two parts, the block and the staff. In setting up, the staff portion is first stuck in the ground at the point desired. Then the block is set on the staff. It is important that the staff be vertical. This may be accomplished with the help of a plumb bob.

Erecting Perpendiculars.—To erect perpendiculars with the staff is not a complicated job. The first thing to do is to set the staff on the course at any desired point, say *O*. When stations *A* and *B* are easily accessible, locate *O* by sighting from either one of the stations towards the other and keep *O* in line. When *A* and *B* are inaccessible, however, locate *O* by one of the following methods:—

First Method.—Set two rods, *a* and *b*, at some distance apart, between *A* and *B*. (*See* Figure 2.) Sight *A* from *a* and bring *b* in line. Then sight *B* from *b* and bring *a* in line. Continue the process until *A*, *b*, *a*, and *B* are all in line. Now set the staff on the course *AB*.

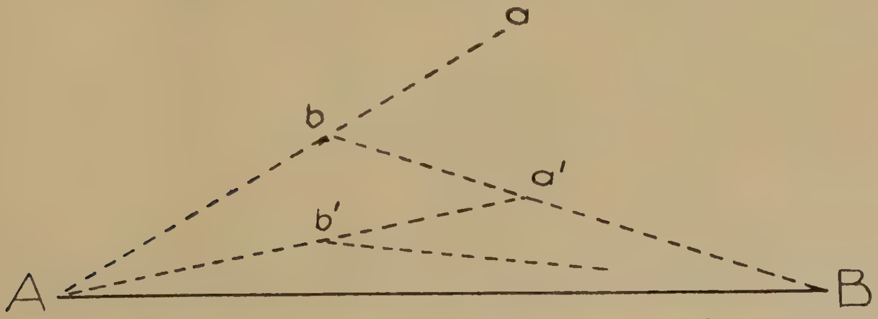


Figure 2.—Locating an accessible point between two inaccessible points.

Second Method.—Set the staff as nearly as possible on the course, *AB*, at *O′*. (*See* Figure 3.) From *O′* sight *B* through one of the slits, then sight back through the slit. If, on sighting back through the slit, *A* is not seen, transfer position of staff, say, to *O″*. From *O″* sight *B* through one of the slits, then sight back through the slit. If, on sighting back through the slit, *A* is not seen, transfer position of staff and continue process until *O′* is in line with *A* and *B*.

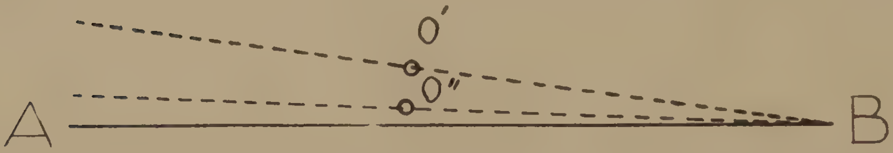


Figure 3.—Locating a point between two points by the use of the surveyor's staff.

Suppose now that the staff is set at a point *O*, on the course *AB*. (*See* Figure 4.) Sight *B* through the slit *m–m* of the block. Then sight to a point *C* through slit *n–n* (Figure 4*a*). Turn the block so that *B* is sighted through slit *n–n*. Then sight through *m–m* to a point *D* (Figure 4*b*). The line bisecting angle *COD* is perpendicular to line *AB*.

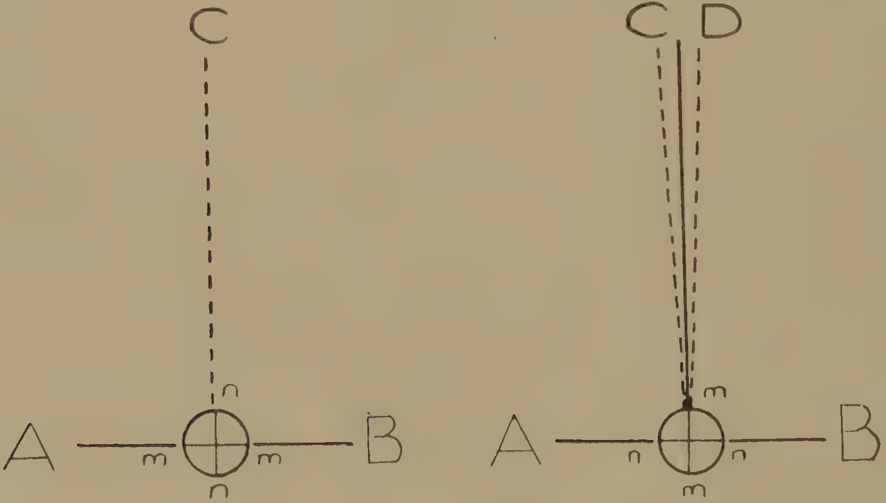


Figure 4.—Erecting a perpendicular.

Finding Areas: A Triangle.—The area of a triangle may be found by multiplying one half of the base by its altitude. The measurement of the altitude is the problem. Suppose we have a triangle *ABC*. Then guess approximately point *O* on *AB* so that *CO* is almost perpendicular to *AB*. (*See* Figure 5.)

Set the staff on point *O*. Erect a perpendicular to *AB* from *O* towards *C*. If *C* is not on the perpendicular, correct the point *O* by moving it by the distance *d* between *C* and the perpendicular.

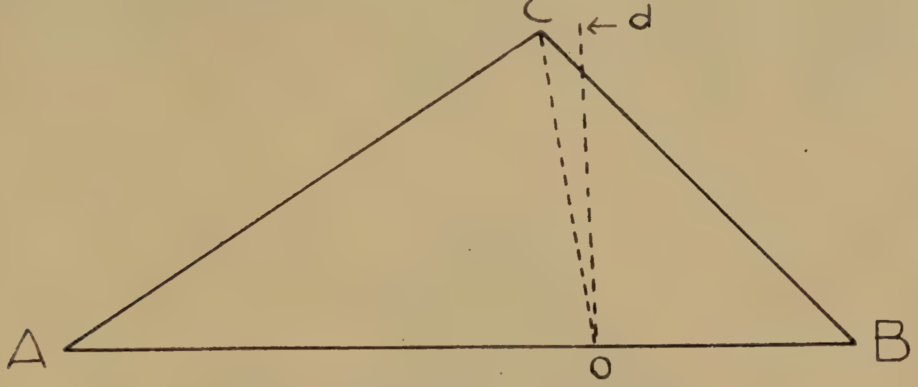


Figure 5.—Determining the altitude of a triangle.

An n-sided Polygon.—The area of an n-sided polygon is the sum of the areas of the triangles into which the polygon may be divided.

An Irregularly Bounded Figure.—The area of a figure with an irregular side may be found by summing up the areas of the trapezoids into which the figure may be divided.

Set a base line through, or by the figure. From the base line erect perpendiculars to the bending ~~points of the boundaries~~ of the figure. Following the course of the boundaries of the figure in a clockwise direction, and supposing all courses due west as negative and courses due east as positive, the areas of trapezoids formed by the base line, the two adjacent perpendiculars, and a course shall be positive or negative depending on the sign that the course carries. The difference between the negative and positive areas is the area of the irregularly bounded figure.

Extension of Lines.—The extension of lines through an obstacle when (1) the two known stations are visible from each other, and (2) the two known stations are not visible from each other, are common problems in fencing, lining and orchard work.

1. *Stations visible from each other.*—Suppose *A* and *B* are the known stations. (*See* Figure 7.) Erect perpendicular *BC* on *AB* from *B*. Then erect perpendicular *CD* on *BC* from *C*. Produce *CD* until the obstacle is passed. Then erect perpendicular *DE* on *CD* from *D*. *DE* must be made equal to *BC*. From *E* erect a perpendicular. This is the required extension of *AB*.

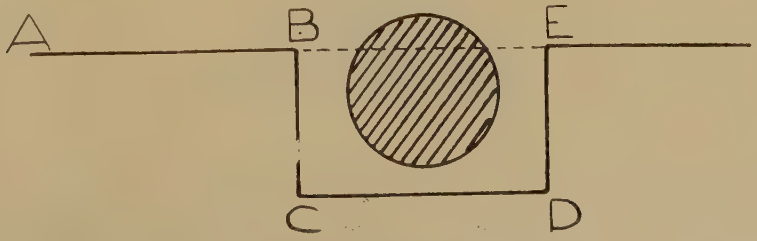


Figure 6.—Extending a line through an obstacle when known stations are on the same side of the obstacle.

2. *Stations not visible from each other.*—Suppose *A* and *B* are the known stations. (*See* Figure 7.) From *A* project a line, *AC*, passing by the obstacle. From *AC* erect a perpendicular to *B*. Then from a point *D* on line *AC* erect perpendicular *DE*, so that *AC/CB* equals *AD/DE*. Then erect another perpendicular from a point *F* on line *AC* to *G*, so that *AC/CB* equals *AF/FG*. Points *A*, *G*, *E*, and *B* are then all in line.

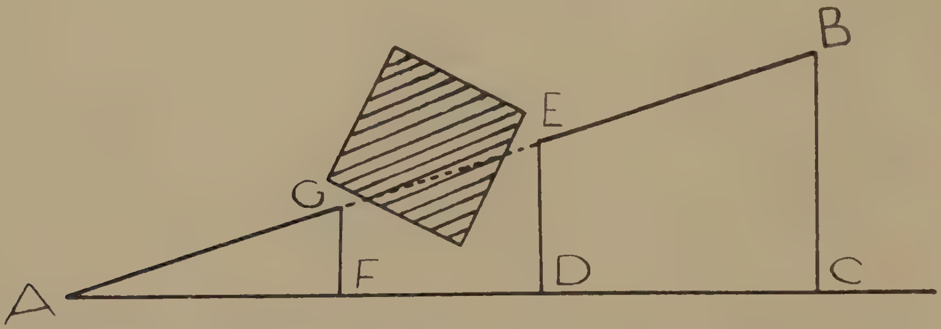
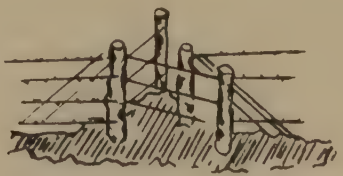


Figure 7.—Setting a straight line between two stations with an obstacle between.

A GATELESS OPENING.

In many places it is desirable to have an opening in the fence that a man can easily slip through without bothering with a gate, but through which horses or cows cannot pass. Four posts are set as shown—two in the fence line, which should be braced, and one each side of one of the centre-line posts. Branch wires are carried from the other centre-line post to the two side posts. These should be made of wire without barbs to catch on the clothes, as it is not desirable to make



the openings larger than necessary. If the centre posts are long enough—say, 5½ or 6 feet above the ground—they can be braced to each other by a piece of strap iron across the top. If this is possible, then the other braces will not be necessary.

REVIEW.

An excellent report on the volcanoes of the Territory of New Guinea was recently published by the Administration. The report (Geological Bulletin No. 2) was written by the Government Geologist, Mr. N. H. Fisher, M.Sc., and may be obtained from the Post Office in Rabaul for 1s. It includes all available information on the volcanoes of the Territory and with the report are numerous well prepared maps which show the locations and extent of the major volcanoes.

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DEPARTMENT OF AGRICULTURE.
TERRITORY OF NEW GUINEA.
RABAUL.

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COMMUNICATIONS.

All communications should be addressed to the Editor, the *New Guinea Agricultural Gazette,* Department of Agriculture, Rabaul.

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EDITORIAL NOTES.

FOR some decades the policy of most countries has been to encourage the local production of staple commodities instead of relying on their importation. To-day, this policy is largely dictated by the international situation, which is restricting the free flow of trade from one country to another. In New Guinea, production for local consumption is small, most of the necessities of life being imported from Australia and overseas. The value of the foodstuffs imported into this Territory is about £300,000 per annum and the value of the foodstuffs of animal origin is approximately half this amount, made up as follows:—

	£
Meat	86,000
Dairy Produce	30,400
Fish	16,700
Bacon and Hams	9,900
Other Animal Foodstuffs	8,900

A diminution in the importation of any of these foodstuffs, particularly dairy produce, through increased local production is most desirable. In the case of dairy produce, local production is not only desirable economically, but necessary to maintain a high standard of health, for milk is the most valuable of all foods and it has been proved that in communities where there is not a good supply of cheap fresh milk, the health of the people is thereby impaired.

The production of milk in the tropics is a subject which has received much attention during recent years. The most fundamental of the many problems connected with it is that concerned with the establishment of breeds of dairy cattle which will live, thrive and produce payable quantities of milk under the severe climatic and environmental conditions existing in tropical countries. The introduction of European breeds into the tropics with a view to their final acclimatization is a practice which has met with little success. The first imported animals may be satisfactory, but successive generations bred in the tropics show progressive degeneration due to causes which have not been fully investigated. Repeated importations of new blood may retard this degeneration but are generally unsatisfactory. The development, by selection, of milking strains within some of the pure breeds of Indian cattle of the Zebu or Brahmin type has met with definite success and it has been stated, that in the proper handling of material available in Southern India, lies the solution to the problems of breeding dairy cattle for the tropics.

Nearly half a century ago, dairy cattle were first introduced into this Territory and although many died shortly after their importation, some survived and to-day their prodigy (over 20,000) are to be found in many coastal districts of the Territory. These cattle were mostly of the Jersey and Guernsey breed imported from Australia, although, it is on record, that occasional cows of the Bali, Zebu and Javanese breeds were also brought into the country. These cattle were imported for the joint purpose of milk production and to keep down grass on the plantations, thereby saving labour. As dairy cattle, they have degenerated pitifully, but they have adapted themselves to their environment and are in good health. Unfortunately, their milk yield is low but, as will be shown in the following article, this is partly the result of inadequate feeding. By proper feeding, selection and perhaps the introduction of new blood from sub-tropical countries, the milk yield could be increased and dairy herds of good grade built up.

The relation between dairying and the copra industry is most complex and before the present war the largest butter producing countries were also the largest margarine producers. This is partly because the by-product from the preparation of copra is an important supplementary fodder and this fodder can be utilized in increasing milk and hence butter production. For the same reason, a similar relation exists between the coco-nut and pig industries. Coco-nut meal or cake is an excellent pig food and in Guam fresh coco-nut meat has been successfully used for feeding growing pigs and brood sows on pasture. Both skim-milk and butter-milk would be excellent supplements to coco-nuts in swine feeding, for these dairy by-products are rich in calcium, phosphorus and proteins of the highest quality.

It is thus seen that there is a definite relation between the copra, dairy and pig industries and once one of these industries has been established, it is advantageous that the development of the other two should follow. Unfortunately, none of these industries has been fully developed in this Territory, although the time should not be far distant when we will be crushing our own copra and seeking the most economical means of disposing of the by-products.

MILK PRODUCTION IN NEW GUINEA.

By R. C. Hutchinson,
Department of Agriculture, Rabaul.

Introduction.

There are no cattle indigenous to the Territory of New Guinea, but during the past forty or fifty years, particularly during the German occupation, cattle were introduced into many parts of the country. A search through old German records (Statistics, German New Guinea, 1916) has revealed that mostly cattle of the Jersey and Guernsey breeds were imported, and the colour and conformation of many of the existing cattle give definite support to this statement. Much care was taken over the importation of these cattle, and the Germans had a government station at Kieta (*Bulletin Imperial Institute,* 1915) for the breeding and distribution of superior types. These cattle have interbred and increased in numbers,(a) so that to-day large mixed herds are to be found on plantations in practically all coastal districts of the Territory. They are never housed and, except in occasional cases where the cattle have access to cover crop, their feed consists only of natural pasture. Nevertheless, they are in fair condition and remarkably free from disease.

The individual milk yield of these cows seldom averages much more than one quart a day at any stage of their lactation period, so that they are not worth milking, except in cases where planters milk three or four to supply their own household requirements. The mean yield per cow of fifteen herds on different plantations was only 1.1 quarts per day, which is even lower than the yield from the poor, inefficiently producing, native cows of Ceylon and South India (Bruce, 1922; Crawford, 1938, and Bunting and Marsh, 1934).

Less than four years ago, a small herd of pure-bred Friesian cattle was imported from Australia for the purpose of supplying fresh milk to Rabaul. This is the only herd, producing milk on a commercial basis, in the coastal districts of the Territory. The average daily milk yield of this herd throughout the year is about half a gallon per cow, although, in May, 1940, 28 cows thoroughly milked were only giving 12 gallons per day, but at that time several of the cows had their calves running with them during the day, so that the actual yield was slightly higher than this amount. The standard daily yield for a Friesian cow in a temperate climate is 3.2 gallons (Bulletin 52, Ministry for Agriculture and Fisheries, 1937), and the original cows in this herd were giving from three to four gallons a day before their importation.

Because of these low yields, dairy farming in New Guinea is a most unattractive proposition, and although there are many centres in which sufficient people live to support one or even more dairies, there are only three dairies selling milk in the whole of the Territory. One is situated near Rabaul, and two in the high inland mining town of Wau, where climatic conditions are more conducive to dairying, being quite different from those in the coastal districts of the Territory.

(a) In 1909, there were less than 1,000 cattle in New Guinea (Amtsblatt f. Neu-Guinea vom 15. Sept. 1909) and to-day about 21,000 have been accounted for (Report on Administration of Territory of New Guinea, 1938-39) and there are many more. The increase has been mostly a natural one.

The object of this investigation was to show that these low milk yields are largely the result of inadequate feeding, and to indicate how the yield could be improved.

Climatology.

To understand fully the circumstances surrounding this investigation, it is necessary to know something of the climatic conditions of the coastal districts of New Guinea, where practically all cattle are located.

The Mandated Territory of New Guinea is situated 141° to 156° east longitude, and approximately 0° to 8° south of the equator, and, except for the high inland areas of the Mainland, its climate is typically tropical in the narrowest sense of the word. On the smaller islands and along the coastal belts of the Mainland, New Britain, New Ireland and Bougainville Island, where most agriculture is practised, the climate is hot and humid. There are no distinct seasons, although more rain falls when the north-west monsoons prevail, from December to April, than during the remainder of the year. The average rainfall varies from 100 to 300 inches per annum. The mean temperature is approximately 82° F. at all periods of the year. The greatest difference between the highest and lowest barometer readings during the year seldom exceeds 10 millibars. From observations taken over a period of years at five main coastal weather stations, the average relative humidity was found to be 81 per cent. at 9 a.m., 75 per cent. at 3 p.m., and 88 per cent. at 9 p.m. The average soil temperatures, taken at a depth of 9 inches in the Botanic Gardens in Rabaul, were 84° F. at 9 a.m. and 85° F. at 3 p.m., and these readings seldom varied by more than about 4° F.

It is thus seen that the climate of the coastal districts is entirely lacking in the seasonal variations found in more temperate zones.

Composition and Properties of Milk.

Table I. gives the composition of 70 mixed milk samples from the pure-bred Friesian herd to which reference has already been made, and 42 from other mixed herds in the Territory.

TABLE I.—AVERAGE COMPOSITION OF NEW GUINEA MILK.

Herd.	Total Solids.	Fat.	Solids-not-fat.	Specific Gravity.
	Per cent.	Per cent.	Per cent.	
Friesian	13.13	4.82	8.31	1.0298
Mixed	13.56	6.28	7.27	1.0290

Methods of Analysis.—Specific gravity was determined with a Westphal balance and corrected for temperature using the author's equation (Hutchinson, 1940). Fat was estimated by Richmond's (1930, *a*) modification of the Roese Gottlieb method, total solids by the evaporation of 10 c.c. of milk and solids-not-fat by difference. Normally, if the fat content and specific gravity were known, the total solids and hence solids-not-fat could be calculated from Richmond's formula (1930, *b*), but it has not yet been shown that Richmond's formula holds equally well under tropical and temperate conditions; in fact, there is evidence to the contrary. Calculating total solids by Richmond's formula for milk from the Friesian and mixed herds, we have 6.18 and 7.94 per cent. respectively. These figures are much lower than those found by direct estimation.

Discussion of Results.—Comparing the figures given in Table I. with those given by Morrison (1938, a), Richmond (1930, c) and Davies (1939, a), it will be seen that the solids-not-fat content and the specific gravity of the New Guinea milk is low, while the fat content tends to be high. A high fat content is to be expected, for it will be shown later that the pastures in the coastal districts of New Guinea are rich in carbohydrates, and it has been proved (Mackintosh, 1938, a) that the fat of milk is largely formed from the carbohydrates supplied in the feed. Furthermore, many of the mixed herds contain Jersey and Guernsey blood, and these breeds of cattle are noted for giving milk of high fat content.

The low specific gravities are accounted for as follows: The melting point of butter fat is about 86° F., so that it is liquid when drawn from the cow and, under the atmospheric conditions prevailing in New Guinea, solidification takes place so slowly that it remains in the liquid state during the day it is drawn, generally solidifying in the evening. It has been shown (Richmond, 1930, d) that the specific gravity of butter fat in the liquid state is lower than when in the solid state; so that the specific gravity of milk, in which the butter fat is in the liquid state, will be lower than when the butter fat solidifies. The low solids-not-fat content of the milk would also lower the specific gravity slightly.

The low solids-not-fat content appears to be general for milk produced in the tropics. Wright (1916-22) has recorded normal values a little over 8 per cent. for the solids-not-fat content of milk produced near Suva, whilst Southall (cited by Blackie and Flemons, 1939) made a series of determinations on milk from local suppliers in Fiji, and his figures indicate a wide variation in solids-not-fat tending to an average of 8.3 per cent. Further work in Fiji, by Blackie and Flemons (1939), shows the mean solids-not-fat content of mixed milks collected over a period of one year to be 8.33 per cent. French and Raymond (1936) have indicated a similar state of affairs in Tanganyika, stating that over 25 per cent. of the grade cows regularly give milk which contains less than the arbitrary legal limit of 8.5 per cent. solids-not-fat. In Mauritius (Annual Report, Department of Agriculture, 1938), the mean solids-not-fat content of a large number of mixed milk samples collected at different periods of the year was 8.4 per cent. In the Philippines (*Handbook of Philippine Agriculture*, 1939, a), where a number of milk samples from cows of different breeds have been analysed, similar results were also obtained. The mean of four analyses of milk from Holstein cows gave a protein plus lactose content of 7.42 per cent., and 37 samples from half Nellore-half Holstein cows gave 7.52 per cent.

Low Solids-not-fat—Probable Causes.—This lowering of the solids-not-fat may be due to several causes. It may be a natural adjustment brought about by the physiological necessity of secreting a liquid lower in calorific value to suit the naturally smaller needs of a suckling in a warm climate or it may be due to disease or faulty nutrition. The first cause seems unlikely as the fat content tends to be high, although there is the possibility that this high fat content may be due to other causes of difficult physiological control, for the fat content of milk is more readily changed than the solids-not-fat. If the second cause is responsible, it could almost certainly be detected by analysis, for the solids-not-fat are usually altered in composition by digestive ailments and by disease (Bergema, 1919).

The results of the analyses of the solids-not-fat fractions of 25 milk samples are given in Table II. Protein was estimated by the method outlined by Davies

(1939, *b*); lactose by the Fehling's Solution method outlined by Richmond (1930, *e*) and chlorine by Massot and Lestra's (1936) third method.

Reference will be made later to the mixed herds from which samples 11 to 25 were collected, for it was on these herds that determinations of weight were made and it was the pastures upon which they were feeding which were analysed.

These figures are not abnormal, although the lactose content is perhaps low and the chloride content a little high. Davies (1939, *c*) gives the normal lactose content of milk as 4.8 per cent. He also gives the normal chloride content of morning milk as ranging from 81 to 90 mgms. per 100 ml. (Davies, 1938), and, for samples from Friesian herds known to be giving milk low in solids-not-fat, the mode of the frequency distribution was 110 to 120 mgms. per 100 ml. A low lactose content accompanied by a high chloride and ash content is generally considered as indicative of disease or of digestive ailments. Mathieu and Ferré (1914) have found that the lactose (grams per litre) plus the lactose equivalent of the chlorides as NaCl (NaCl × 11.9) in grams per litre does not fall below 70 in a normal milk. They have termed this figure the "*constant moléculaire simplifiée*", (c.m.s.). Koestler (1922) has suggested that the value 100 × per cent. Cl. ÷ per cent. lactose ("Koestler number") is of value in diagnosing milk from cows with diseased udders or otherwise giving abnormal milk. The value for

TABLE II.—COMPOSITION OF THE SOLIDS-NOT-FAT FRACTION OF NEW GUINEA MILK.

No.	Herd.	Protein.	Lactose.	Ash.	Chloride.	
		Per cent.	Per cent.	Per cent.	Per cent. Cl.	Per cent. NaCl.
1	Friesian	3.06	4.42	.67	.136	.224
2	„	2.97	4.29	.68	.146	.241
3	„	3.15	4.55	.70	.127	.209
4	„	3.16	4.62	.71	.121	.199
5	„	3.06	4.40	.68	.123	.203
6	„	3.07	4.45	.69	.140	.231
7	„	3.16	4.67	.70	.118	.194
8	„	3.24	4.68	.72	.117	.193
9	„	3.17	4.59	.71	.124	.204
10	„	3.12	4.51	.69	.130	.214
Mean	..	3.12	..	..	..	..
11	Mixed	2.39	3.46	.56	.198	.327
12	„	2.86	4.13	.64	.158	.261
13	„	3.11	4.49	.69	.131	.216
14	„	3.21	4.64	.71	.121	.200
15	„	2.08	2.96	.46	.244	.402
16	„	2.94	4.24	.65	.151	.249
17	„	2.80	4.04	.62	.164	.270
18	„	3.12	4.50	.69	.131	.216
19	„	2.80	4.25	.68	.149	.246
20	„	3.21	4.40	.69	.138	.228
21	„	2.19	3.17	.50	.201	.331
22	„	2.62	3.80	.58	.183	.302
23	„	2.72	4.00	.59	.164	.270
24	„	2.93	4.04	.67	.164	.270
25	„	3.12	4.56	.70	.133	.219
Mean	..	2.81	..	..	..	..

normal milk is usually less than 2 and milk samples giving values above 3 may be regarded as abnormal, the latter value applying to milk containing .14 per cent. Cl and over. Computing the c.m.s. and Koestler number for the milk samples analysed, the results given in Table III. were obtained.

TABLE III.—C.M.S. AND KOESTLER NUMBER FOR NEW GUINEA MILK.

Friesian.			Mixed.		
No.	c.m.s.	Koestler No.	No.	c.m.s.	Koestler No.
1	70.9	3.1	11	73.5	5.72
2	71.6	3.4	12	72.4	3.82
3	70.4	2.8	13	70.6	2.92
4	69.9	2.6	14	70.2	2.61
5	68.2	2.8	15	77.4	8.24
6	72.0	3.1	16	72.0	3.56
7	69.8	2.5	17	72.5	4.06
8	69.8	2.5	18	70.7	2.91
9	70.2	2.7	19	71.8	3.51
10	70.6	2.9	20	71.1	3.13
			21	71.1	6.34
Mean	70.3	2.8	22	73.9	4.82
			23	72.1	4.10
			24	72.5	4.54
			25	71.7	2.92

Neither the c.m.s.'s nor the Koestler numbers for milk samples from the Friesian herd suggest that these cows were suffering from disease or digestive ailments, particularly as the ash content is low. The c.m.s.'s and Koestler numbers for samples 1, 2 and 6 are slightly above 3 and 70 respectively, but not appreciably high.

The milk samples from the mixed herds gave widely differing c.m.s.'s and Koestler numbers, the majority being abnormally high. The wide difference to be found in these figures is due no doubt to the fact that the samples were not from the bulked milk of herds of normal size, but generally from only three or four cows, so that individual variations might not have been completely eliminated. The reason for most of the figures being high is accounted for by the fact that the chloride content of the samples was correspondingly high. Davies (1932) has made detailed analyses of milk samples from healthy cows which were giving milk low in solids-not-fat and he found that the constituent mostly responsible for the deficiency was lactose and that invariably samples low in solids-not-fat and thus lactose are high in chlorides due to the fact that the maintenance of the osmotic pressure of the milk is affected by the substitution of ionized chlorides for lactose. Thus it is normal for these samples, low in solids-not-fat, and hence lactose, and high in chlorides to have high c.m.s.'s and Koestler numbers. This and the fact that the ash contents are low give no indication that these milk samples were from diseased cows or from cows suffering from digestive ailments.

The third possible cause will now be considered. In an excellent paper, "The Effect of Type of Feed on the Solids-not-fat Content of Milk", Roux, Murray and Schutte (1935) fed one group of six cows a heavy concentrate ration, a second group a heavy dry ration and a third group a heavy succulent ration.

The heavy concentrate ration maintained a higher level of production, a normal trend of solids-not-fat and a slow increase in percentage of butter fat with advance in lactation. The other rations appeared to have a depressing effect on the percentage of solids-not-fat and milk production dropped more rapidly and the percentage of butter fat increased to a greater extent than occurred in the heavy concentrate group.

During a period of three years, Cranfield (1927) studied variations in the solids-not-fat content of a herd of Shorthorn cows which frequently gave milk low in solids-not-fat. Feeding was found to be one factor which influenced the solids-not-fat content of the milk.

As a result of four years' investigation with a herd of cows, it has been shown (Trambics, 1938) that the percentage of solids-not-fat drops in summer months, the drop being more marked the severer the summer. It is considered that this drop is partly the result of a change in the sugar and protein content of the feed.

The results of these investigations indicate that poor feeding could be at least partly responsible for lowering the solids-not-fat content of milk. It will be shown presently, that the feed upon which New Guinea cows are feeding is often very low in nutritive value and it seems highly probable that these low figures for solids-not-fat are partly or wholly the result of faulty nutrition. In fact, it is probably for this reason that low solids-not-fat are more common in the tropics than in temperate climates, for in temperate climates pastures are, in general, more nutritive (see Table V.) and the practice of feeding concentrates is more common.

Factors Effecting Milk Yields.

Miscellaneous Factors.—The amount of milk a cow produces is effected much more readily and to a greater degree than its composition. There are several factors which might be contributing towards low milk yields in New Guinea but, as will be shown presently, there is one factor which appears to greatly outweigh all others. It must be understood, however, that with the exception of the recently introduced Friesian herd, the cows are producing approximately as much milk as their dams which is probably their inherited capacity. After the introduction of the first cattle, each succeeding generation has probably produced a little less milk than the previous one, until a state of equilibrium has been reached in relation to their environment. Therefore, the low milk yields are the result of factors which have been operative over a number of cow-generations.

New Guinea cows are only milked once a day, in the early morning. An attempt was made to increase the production of the Friesian herd by milking twice daily, but the dairyman considered that the slight increase in yield was not sufficient to justify the extra labour involved.

The cattle are generally milked by natives, for most New Guinea cattle, with the exception of the Friesian herd, are too timid and frightened to be even approached by a white man. There is a possibility that the natives may not strip the cows as thoroughly as desirable, although the milk is generally high in fat and most fat is contained in the strippings (Van Slyke, 1908 and Eckles (—)).

The only complaint from which any of the cattle appear to be suffering is tick infestation, although they appear to be immune to tick fever. But ticks in New Guinea cattle are not common, although, unfortunately, they are spreading, and of the sixteen herds under observation during this investigation only one was found to be infected with them. Hence, although it is known that ticks do lower milk yields (Maynard, 1931), they are not responsible for low yields in the present instance.

For a cow in good health, the maximum yield is usually reached at 7 to 9 years of age but there is usually no marked decline in yield until she is about 12 years of age (Morrison, 1938, *b*). None of the cows under observation during investigation was more than 6 or 7 years of age.

If the weather is too hot for the comfort of the cows, it may cause a slight but decided reduction in yield, together with an increase in the fat content and other changes in the composition of the milk. Experiments have shown that such an effect is produced when cows are kept in an atmospheric temperature above 85° F. for more than 48 hours (Regan *et al.*, 1934). High humidities may also cause a drop in yield, high producing cows being more effected than low producers (Bender, 1928). The temperature in New Guinea frequently reaches 85° F. but remains there only for a relatively short time and, as the cows are all low producers, neither temperature nor humidity should effect milk yields to more than a small extent.

Cows imported into a tropical country are more susceptible to heat than those born there. In the case of exotic breeds, it has been shown (Bonsma *et al.*, 1940) that as soon as the atmospheric temperature rises above 80° F., it is accompanied by a rise in the body temperature and a considerable increase in the respiration count. The respiratory centre loses its normal function of controlling the rhymthmical movement of respiration, the breathing consequently becoming rapid, irregular and shallow. Such factors would almost certainly have a disturbing influence on the delicate mechanism of milk production, in the imported Friesian cows.

Dietary Factors.—During a preliminary investigation into the low milk yield of New Guinea cows, the herd of Friesian cattle was fed concentrates imported from Australia in addition to being grazed all day. The concentrate was mixed with chaffed elephant grass (*Pennisetum purpureum*) and the amount fed depended approximately upon the individual response of each animal. It was found that during a very short time, the milk yield could be increased more than 30 per cent. This suggested that the cause of the low milk yield was partly dietary. Consequently, it was decided to investigate the diet of these cows and this led to a determination being made of the nutritive value of the more common grasses and fodder crops found in the coastal districts of New Guinea.

Nutritive Value of Fodder Crops.—It is well known that different grasses and legumes vary widely in nutritive value. Even plants of the same species may vary considerably in composition depending upon their habitat and stage of maturity. For instance, immature grass is relatively high in protein and low in crude fibre. As the grass matures, the percentage of protein decreases and that of crude fibre increases. Hence, a pasture that grows considerably faster than it can be consumed, will soon have a stand of mature grass, high in fibre but low in nutritive value. In recent years, the work of Woodman and associates at Cambridge has emphasized the value of immature grass for feeding purposes and milk production.

In New Guinea, particularly on plantations along the coastal belts, there are extensive areas of green, succulent and apparently nutritious pastures. Because of the climatic conditions, there is no period of maximum growth, but plants are growing rapidly all through the year and consequently these pastures consist of a high proportion of mature grass. Cattle do not graze these pastures indiscriminately but generally seek the younger grass, of which there is only a very limited amount. This necessitates their covering extensive areas each day.

On plantations the grass is cut periodically, but it commences growing immediately and within a very short time reaches maturity again. If there are cattle on the plantation, it is probable that they will not have availed themselves of the opportunity of grazing on the freshly cut areas, for most tropical cattle are of a very nervous and timid disposition and generally migrate to those parts of the plantation where there is least activity and excitement. It would be too expensive to enclose the cattle within fenced areas, for timber is frequently scarce and the areas would have to be large and the fences substantial.

Samples of the more common grasses and sedges of which New Guinea pastures are composed have been collected and analysed. These samples were divided into mature and immature samples. By mature grass is meant grass at or past the flowering stage and by immature grass is meant young grass which is sufficiently high to be easily grazed, but which shows no sign of flowering. Each sample analysed was taken from a number of pooled samples collected from one locality, although, in some cases, it was not possible to collect corresponding mature and immature samples from the same locality.

Sixteen samples of mixed pastures were also collected and analysed, but, as has already been pointed out, whenever possible, cattle eat only the immature grass. They also show preference for certain grasses. For instance, they will never eat Kunai (*Imperata arundinacea*), no matter how young and succulent it may be, if there are other grasses available. Thurston grass (*Paspalum conjugatum*), is perhaps the most common pasture grass in the Territory and on some plantations it is the only grass. Couch grass (*Cynodon dactylon*) is relished by cattle and is plentiful around Rabaul, although comparatively rare in other parts of the Territory. Because of these facts, samples of the more nutritious and succulent portions of these sixteen pastures were also collected and analysed for moisture, crude protein and digestible crude protein. These unavoidably contained some mature grass but they were very similar to those eaten by the cow. They were not cut, but plucked by hand in order to simulate a cow's method of grazing.

All estimations were made in duplicate on the fresh samples, 5 grams being taken for each determination. Crude protein, which was estimated in preference to true protein for reasons to be given later, is nitrogen × 6.25. Crude fibre was estimated by the method given in Allen's *Commercial Organic Analysis* (1937). The ether-soluble extract was determined in a Soxhlet extractor, moisture in a hot air oven at 105° C. and sugar and starch (or nitrogen-free extract), were computed by difference. The results of these analyses are presented in Tables IV. and VI.

TABLE IV.—COMPOSITION OF NEW GUINEA PASTURES, GRASSES AND SEDGES.

Common Name.	Scientific Name.	Water.	Crude Fibre.	Sugar and Starch.	Crude Protein.	Eth. Sol. Extract.	Ash.	Nature of Specimen.	No. of Analyses.
		%	%	%	%	%	%		
Kunai ..	*Imperata arundinacea* ..	61	14.8	19.7	1.3	0.4	2.8	Immature ..	3
		48	18.4	29.0	0.8	0.3	3.5	Mature	3
Thurston ..	*Paspalum conjugatum* ..	82	4.9	7.0	3.2	0.7	2.2	Immature ..	3
		74	7.4	14.4	1.5	0.4	2.3	Mature	3
Nut ..	*Cyperus rotundus* ..	78	6.5	10.5	2.4	0.2	2.4	Immature ..	3
		67	10.4	17.9	1.9	0.2	2.6	Mature	3
Love or Seedy	*Chrysopogon aciculatus* ..	69	9.0	15.2	3.4	0.4	3.0	Immature ..	3
		61	13.3	20.7	1.8	0.2	3.0	Mature	3
Couch ..	*Cynodon dactylon* ..	66	10.2	16.7	3.5	0.5	3.1	Immature ..	2
		57	12.5	23.7	3.0	0.3	3.5	Mature	2
Elephant ..	*Pennisetum purpureum* ..	89	4.6	2.9	1.2	0.5	1.8	1 ft. high.. ..	1
		86	7.0	4.2	0.7	0.5	1.6	4 ft. high.. ..	1
		62	13.2	21.8	0.5	0.3	2.2	16 ft. high (mature)	1
Karapai ..	*Pennisetum macrostachyum*	81	7.2	6.8	2.3	0.4	2.3	Immature ..	3
		75	12.6	8.4	1.2	0.3	2.5	Mature	3
Pasture ..	.. .. ..	70	10.3	15.4	1.4	0.4	2.5	Mixed	16
		(As percentage of dry matter)							
		..	34.3	51.3	4.7	1.3	8.3	Mixed	16

In order to compare the results given in these tables with figures for pastures growing in temperate climates, Table V. has been compiled. This table gives the chemical composition of a number of mixed pastures used for the grazing of dairy cattle in some of the more prominent milk-producing countries.

Comparing the figures in Tables IV. and VI. with those in Table V., it is seen that the protein content of New Guinea pastures, when the whole pasture is sampled, is appallingly low. When mostly the younger portions of the pastures are sampled the protein content is nearly double and, considering New Guinea pastures are unimproved natural pastures, for the most part growing on loose, easily leached soil, it is considered that these results would probably be in good agreement with results obtained for pastures growing under similar conditions in temperate climates. The ash and ether-soluble extract are also low; there is no appreciable difference in the starch and sugar content and the fibre content is, in general, higher. These differences are largely accounted for by the fact that the samples contained a high proportion of mature grass.

Pasture Digestibility.—A chemical analysis is not in itself sufficient for the determination of the nutritive value of a feed. The proportion of the feed which is digestible is also required to be known.

When the digestibility of a feed is determined biologically it is generally assumed that the whole of the dung consists of undigested food. This is incorrect, for faeces always contain metabolic waste products. Attempts have been made to determine the amount of metabolic residue in the faeces by feeding a nitrogen deficient ration. Kellner (1880), working with herbivora, suggested a value of .4 gram of nitrogen per 100 grams of organic matter digested. Pfeiffer (1883-87) carried out a number of experiments with pigs and the figures he obtained agreed with Kellner's value for herbivora. However, it has since been shown (Ashton, 1936; Morgen *et al.*, 1914, and Mitchell and Hamilton, 1929) that a definite figure cannot be accepted for the metabolic nitrogen of all rations for the figure varies

TABLE V.—COMPOSITION OF PASTURES IN TEMPERATE CLIMATES.

Country.	Season.	Water.	Crude Protein.	Crude Fibre.	Sugar and Starch.	Ash.	Ether Extract.	No. of Estimations.	Reference.
		%	%	%	%	%	%		
(Results expressed as percentage of green matter.)									
Australia ..	Summer	..	9.87	..	..	..	..	19	Hutchinson (1939, a)
South Africa..	Summer	..	7.0–9.0	..	..	..	..	..	du Toit *et al.* (1940)
South Africa..	Winter	..	3.3–4.0	..	..	..	..	..	du Toit *et al.* (1940)
America ..	..	74.2	4.7	5.3	12.0	3.2	0.7	86	Newlander *et al.* (1933)
America ..	..	71.3	5.7	6.4	12.8	2.7	1.1	262	Morrison (1938, *c*)
America ..	..	69.8	4.7	6.5	14.5	3.7	0.8	40	Morrison (1938, *c*)
South America	..	75.6	3.7	6.5	10.8	2.6	0.8	179	Morrison (1938, *c*)
(Results expressed as percentage of dry matter.)									
South Australia	..	..	8.0	29.6	51.4	9.5	1.6	..	Davies *et al.* (1934)
England ..	Spring	..	11.3	24.0	53.6	8.3	2.8	35	Moon (1939)
England ..	Winter	..	13.4	28.3	49.6	6.0	2.7	14	Thomas and Boyns (1936)
Canada ..	..	5.3	14.7	24.3	..	..	..	..	Crampton (1934)
America ..	..	..	17.5	23.4	46.5	8.3	4.9	..	Woodward (—)

with different feeds fed in different ways, nevertheless Pfeiffer (*loc. cit.*) concluded from his experiments that the nitrogenous products of metabolism must be taken into account in determining the protein digestibility in animal experiments.

Efforts to determine the digestibility of a food *in vitro* have been successful in the case of protein. This has been effected by artificial digestion in acid gastric juice and has served to determine the total protein which is digestible. Such determinations, however, tend to measure the true digestibility in the digestive tract rather than the effective digestibility as measured by animals.

Pfeiffer (*loc. cit.*) carried out experiments to determine the crude protein digestibility of certain feeding stuffs (1) with animals, (2) by artificial digestion and (3) with the value obtained in the animal experiment corrected for the nitrogen-containing metabolic residues. There was excellent agreement between the values obtained in the artificial digestion and the values obtained in the animal trials when corrected for the metabolic residue in the faeces. More recently (Watson and Horton, 1936), a ration of artificially dried grass was fed at the plane of nutrition to six sheep. The digestibility coefficients obtained by the different methods were:—

Animal experiments uncorrected for metabolic residues ..	63.30
Animal experiments corrected for metabolic residues ..	76.24
Artificial digestion	76.95

This also shows excellent agreement between figures obtained by the last two methods.

The main objection to the artificial methods is that the digestibility of certain protein constituents encased in very tough or fibrous cells is included in the determination, whereas, in actual practice, this protein may pass through the animal undigested.

In New Guinea there are two animals available for digestibility trials, the cow and the goat, but climatic conditions, insect pests, and the temperament of the New Guinea cows and goats do not permit digestibility trials being carried out satisfactorily and with the necessary accuracy. Hence, in the present instance, it was considered that more reliable results could be obtained by an *in vitro* method rather than a biological method carried out under such unfavorable conditions. The method chosen was that recently employed by Schwarze (1937) in determining the amount of digestible protein in lucerne plants and various seeds. The digestion was carried out with pepsin-hydrochloric acid and pancreatin-soda mixtures.

Figures giving the amount of digestible crude protein in the more nutritious portions of the sixteen previously mentioned pastures are included in Table VI. The average amount of digestible crude protein in the first fifteen samples was 1.65 per cent. and for the sixteenth sample, which was collected from the pasture upon which the Friesian herd was grazing, 1.66 per cent.

It is interesting to compare the average figure for digestible crude protein given in Table VI. with figures for pastures in more temperate climates. For this purpose Table VII. has been compiled. It must be remembered, however, that, although the results were obtained from the most nutritious portions of the pastures, they were natural, unimproved pastures containing no introduced grasses or legumes of high nutritive value, whereas the English and American figures were probably for improved pastures.

TABLE VI.—PARTIAL ANALYSES OF THE MORE NUTRITIOUS PORTIONS OF NEW GUINEA PASTURES.

No.	Moisture.	Crude Protein.	Digestible Crude Protein.	
	Per cent.	Per cent.	Per cent. Fresh wt.	Per cent. Dry wt.
1	79	3.1	2.33	..
2	75	2.5	2.03	..
3	69	2.0	1.46	..
4	72	1.8	1.31	..
5	74	2.1	1.55	..
6	76	3.5	2.70	..
7	68	1.9	1.31	..
8	71	2.9	2.03	..
9	67	1.4	0.91	..
10	74	2.1	1.49	..
11	78	2.2	1.56	..
12	69	2.0	1.44	..
13	66	1.7	1.19	..
14	72	2.2	1.58	..
15	78	2.4	1.90	..
Mean	73	2.3	1.65	6.1
16	76	2.6	1.66	6.9
Mean of all results ..	73	2.3	1.65	6.1

From these results it is seen that the digestible crude protein content of New Guinea pastures is low, although approximately the same as for the best Queensland pastures. However, if the results for Queensland and New Guinea pastures were exactly comparable, it is probable that the New Guinea figure would be lower. By comparing values for the best pasture in each country, it is interesting to note that the digestible crude protein content appears to increase as the climate becomes more temperate. The reason for this may be that pasture improvement is practically unknown in tropical countries and is not as common in sub-tropical as in temperate climates.

TABLE VII.—DIGESTIBLE CRUDE PROTEIN CONTENT OF PASTURES.

Country.	Climate.	Digestible Crude Protein.	Remarks.	Reference.
		Per cent.		
New Guinea	Tropical ..	1.65	Young	This investigation
Queensland	Sub-tropical ..	1.6	Best	Brünnich (1926)
United States of America (southern)	Sub-trop.-temp.	2.6	Fertile	Morrison (1938, *d*)
United States of America ..	Temperate ..	3.3	Poor to fair ..	Morrison (1938, *d*)
United States of America	Temperate ..	4.4	Fertile	Morrison (1938, *d*)
England	Temp.-cold ..	2.2*	Extensively grazed	Mackintosh (1938, *b*)
England	Temp.-cold ..	4.4*	Closely grazed ..	Mackintosh (1938, *b*)

* Calculated.

Weight of Cows.—Suitable scales for weighing the cattle were not available so that their weights had to be determined indirectly.

Kendrick and Parker (1936) have compiled a table for estimating the live weights of dairy cattle from heart-girth measurements based on a study of 1,721 actual weights and heart-girth measurements of Holstein and Jersey cattle. A similar table has also been compiled by Ragsdale and Brody (1935) in which the estimated live weights for a given heart-girth are somewhat lower than those given by Kendrick and Parker (*loc. cit.*). Other methods of live-weight estimation have been suggested in the *Queensland Agricultural Journal* (1910), by Singh (1933), and by Dmitrochenko (1926).

Morrison (1938, *e*), in his standard work *Feeds and Feeding,* recommends the method of Kendrick and Parker (*loc. cit.*) for estimating live weight of dairy cattle and this method undoubtedly has advantages over the other methods. The live weights of sixteen groups of New Guinea cows from whom milk was obtained are given in Table VIII. In general, each group of cattle measured was typical of the whole herd.

New Guinea cows vary in size somewhat although, generally speaking, they are small, being about the size of a small Jersey cow. There are indications that the first importations were probably larger for, when the Friesian cows were imported from Australia almost four years ago, they were healthy and of normal size but the offspring of these cows have apparently ceased growing at less than 900 lb. live weight.

TABLE VIII.—LIVE WEIGHTS OF TYPICAL NEW GUINEA MILCH COWS.

No.	Mean Heart-girth Measurement.	Mean computed Live Weight.	Numer of Cattle measured.
	inches.	lb.	
1	62	700	4
2	60	637	4
3	55	501	4
4	59	607	20
5	70	987	4
6	57	552	2
7	65	800	3
8	63	732	3
9	66	835	2
10	67	871	5
11	64	760	4
12	59	607	6
13	62	700	3
14	65	800	4
15	58	579	5
Mean	62	711	..
16	68	910	17

Pasture Consumption per Cow.—This may be determined by comparing the yield of clippings obtained from a grazed area immediately after the grazing trial with the clippings from a similar ungrazed check area, or, it may be determined by feeding a known weight of pasture to a cow in an enclosure, weighing the unconsumed portion at the expiration of a certain time and computing the feed consumed by difference. There are disadvantages to both methods. In the former, the assumption must be made that the grazed and check areas are identical and, unless an elaborate experiment is planned, this assumption may be far from the truth. While in the latter, a cow, which readily submits to stall feeding, would almost certainly consume more pasture if the pasture were already cut, than if the cow had to expend additional energy in grazing it. In this investigation, the latter method was chosen, for there was neither the necessary grass-cutting machine, nor experimental paddocks available with which to carry out estimations by the first method.

The feeding trials were conducted with the assistance of Brother Wochner at the Vunapope Catholic Mission at Kokopo where there is a herd of about nine hundred cattle, twenty of which are milked daily. These cows were quite typical of the majority of New Guinea cows and the daily milk yield averaged about 1 quart per cow. The cows were only milked once a day.

Before satisfactory results were obtained a considerable amount of preliminary experimentation was found necessary. After the first trial, it was found that even approximate values for the normal amount of pasture consumed during a given period could not be satisfactorily determined. Young pasture which had been obtained from areas in which the cows frequently grazed, was stall-fed to selected cows, but within a very short time after it had been plucked, and before it could be consumed by the cow, the pasture lost its freshness and became limp and dead in colour and the cows would not eat it.

It is a common habit in New Guinea to feed cows whilst milking them and it has been found that they relish fresh young bananas, in fact, the cows are loath to leave their stalls while any banana still remains in the feeding box. This allowed determinations to be made of an upper limit to the amount of feed, and hence dry matter, which cows will consume in 24 hours. By an upper limit is not necessarily meant the maximum amount of feed which the cows will consume in 24 hours but an amount which is in excess of that usually consumed by a cow on pasture during this period.

For the second preliminary experiment two cows each weighing about 700 lb. were chosen. In the early morning these cows were milked, and hand fed as usual and then instead of being turned out into the plantation to graze they were allowed to remain in their stalls for 24 hours, being fed from time to time throughout the day weighed quantities of fresh feed consisting of one part by weight of pasture and two parts by weight of freshly cut bananas. At dusk sufficient feed was fed to last until morning, and at the expiration of 24 hours the unconsumed feed was weighed. The cows had access to a common feeding box and were fed water *ad libitum*. The amount of feed consumed per cow was a little less than 50 lb.

During the trial, the stall fed cows had access to feed during the whole 24 hours and they appeared to take full advantage of it, whereas, if they had been turned out to graze, as usual, they would have been driven some distance before any feed was available and even then, considerable areas would have been covered during the course of the day in order to collect but small amounts of feed. In the heat of the day, the cows usually rest in the shade of any trees which might be nearby, thus losing more grazing time.

Having the above information upon which to work, a more accurate feeding test was then conducted. For this another two cows each weighing 710 lb. (heart-girth 62 inches) were chosen. They were stall fed as in the preliminary experiment with feed consisting of one part by weight of fresh young pasture and two parts by weight of bananas, the mixture having a moisture content of 79 per cent. The feed consumption is given in Table IX., the results being in good agreement with those previously obtained.

A similar experiment, in which chaffed young elephant grass (96 per cent.) and bran (4 per cent.) were fed instead of bananas and pasture, was later conducted with two Friesian cows weighing 910 lb. (heart-girth 68 inches) and the results are also given in Table IX. These cows would not eat the pasture-banana mixture.

TABLE IX.—DAILY FEED CONSUMPTION PER COW.

Experiment.	Fresh Feed consumed.	Moisture Content of Feed.	Dry Matter consumed.
	lb.	Per cent.	lb.
First (cows 710 lb.) ..	45	79	9.5
Second (cows 910 lb.) ..	124	89	13.6

In comparison with food consumption figures for dairy cows in temperate climates (Woodward, 1936) these figures are very low. This is probably due to the scarcity of palatable and nutritious feed, although, it is not to be expected that these animals would be large eaters, for they would then be too susceptible to overheating in a country where atmospheric temperatures are so high.

Digestible Crude Protein Consumption.—From the results of the preceding section and those given in Table VI we have—

Amount of dry matter consumed per day by a cow weighing 710 lb. $<$ 9.5 lb.

∴ Amount of digestible crude protein consumed daily .. $< \dfrac{6.1 \times 9.5}{100}$

$< .58$

Amount of dry matter consumed per day by a Friesian cow weighing 910 lb... .. .. $<$ 13.6

∴ Amount of digestible crude protein consumed daily .. .. $< \dfrac{6.9 \times 13.6}{100}$

$< .94$

Protein Requirements.—Protein requirements for dairy cows have not been determined for cows living under tropical conditions. In the tropics, there is less loss of body-heat due to radiation and conduction than in a colder climate. Hence, slightly smaller amounts of digestible nutrients, particularly fat and carbohydrate, may be required, but it is doubtful whether, in the case of protein, the difference would be sufficiently large to be of practical significance.

In addition to the true proteins, other nitrogenous compounds of a less complex character also occur in feeds in relatively small quantities. These are generally grouped with true protein under the term crude protein.

Some investigators have expressed their results in terms of digestible crude protein, some as digestible true protein and, in 1924, a Departmental Committee of the Ministry of Agriculture and Fisheries in England advocated expressing protein requirements in terms of "protein equivalent", which is the percentage digestible true protein plus one half the difference between the percentage of digestible crude and digestible pure protein.(a)

The lack of justification for stating protein requirements in terms of digestible true protein is emphasized by Forbes (1924), who states that, "The true protein of a feed does not contain all its amino acid fraction, while the crude protein contains all—and much else—some of related character—and some not related. All things considered, the writer favours the continuance of the crude protein standard in the literature of animal production." Morrison (*loc. cit.*) in his standard work, *Feeds and Feeding*, expresses results in terms of digestible crude protein in preference to digestible true protein, the reason for his choice being that "there may be as great a difference in nutritive value between two pure proteins, as there may be between a crude protein and the mixture of these simpler compounds occurring in common foods." McCandlish (1938, *a*), after discussing the best units in which to express protein requirements in feeding standards, sums up by saying, ". . . it appears probable that there is more justification for a feeding standard being based on digestible crude protein rather than on true protein."

The non-protein nitrogenous compounds may be divided into two portions, one consisting of amino acids and their derivations, and the other of simpler nitrogenous compounds. There is no doubt that the amino acids and their derivations contribute towards the protein value of the feed, and it has been pointed out by Mitchell and Hamilton (1929) that the simpler nitrogenous compounds, though probably of no use to carnivorous or omnivorous animals, may perhaps be of some value to ruminants, and their possible value to ruminants is set forth in a paper by McCandlish (1938, *b*.).

In view of these facts, it is concluded that there is more justification for protein requirements being expressed in terms of digestible crude protein than digestible true protein, and because of the small differences to be generally found between digestible crude and digestible true protein and the consideration given above, there appears to be little justification for the term "protein equivalent."

In Table X are given the more recent figures obtained by various investigators for the digestible crude protein maintenance requirements per 1000 lbs. live weight. Where results were expressed in terms of digestible true protein, the conversion was effected by use of the factor 1.2, and protein equivalent was converted by using the factor $\frac{12}{11}$.

(*a*) The relationship between digestible crude protein (C), digestible true or pure protein (T) and protein equivalent (E) may be obtained as follows:—

According to Armsby (1917) .. .. $5C = 6T$

$\therefore C = 1.2T$

And by definition .. .. $E = T + \frac{C-T}{2}$

$= \frac{11C}{12}$

TABLE X.—DIGESTIBLE PROTEIN REQUIREMENTS FOR MAINTENANCE.

Authority.	Date.	Protein Requirements.	Result in Terms of Digestible Crude Protein.
		lb.	lb.
Eckles	1913	.5 true	.6
Haecker	1914	.7 crude	.7
Armsby	1917	.5 true	.6
Hills *et al.*	1922	.6 crude	.6
Buschmann	1923	.45 true	.54
Hansson	1926	.5 true	.6
Möllgaard	1929	.45 true	.54
Morrison(*f*)	1938	.6 crude	.6
Forbes and Kriss ..	1931	.6 crude	.6
Mackintosh(*c*)	1938	.6 Prot. equiv.	.65

In Table X, the majority of figures indicate that for maintenance, a cow weighing 1,000 lb. requires approximately .6 lb. of digestible crude protein daily. During the latter stage of pregnancy, a cow would probably need considerably more than this amount, so that, when dealing with a mixed herd in which there are cows at all stages of pregnancy, slightly more digestible crude protein would be required.

In the tropics, it is possible that protein requirements may be slightly less, for reasons already indicated. On the other hand, there is the possibility that New Guinea cows, which are naturally inclined to be careless in their habits, may not utilize their feed as efficiently as cows in temperate climates, although there are no real grounds for such a supposition. Taking all these factors into account, it seems reasonable to conclude that for maintenance, milch cows in New Guinea require approximately .6 lb. of digestible crude protein per 1,000 lb. of live weight daily.

It has been found that maintenance requirements are more closely proportional to body surface than live weight. The reason for this is that the body loses most of its heat by radiation and conduction from the skin surface, and this loss is proportional to the area of that surface. Also, the weights of the most active tissues of the body, in animals of different sizes, is more closely proportional to the surface of their bodies than to their live weights. Taking these factors into consideration, it has been deduced that if .6 lb. of digestible crude protein per 1000 lb. live weight is required daily, then cows weighing 910 and 710 lb. would require approximately .55 and .45 lb. respectively (Morrison, 1938, *g*).

During recent years, much experimental work has been carried out on the subject of protein requirements for production. Protein requirements for production are generally expressed as so many lbs. of digestible crude protein per 10 lb. of milk containing a certain fat content. No information is given as to the protein content of the milk, for, generally, the results are intended for incorporation in feeding standards where the quality of the milk is judged according to its fat content. The protein content of milk may vary from 3.05 to 3.85 per cent. (Davies, 1939, *d*), and although equations have been obtained connecting the fat and protein content of milk (Kahlenberg and Voris, 1931, and Ohio Station Bulletin 446, 1930), the results obtained are unsatisfactory. Hence, most experiments planned to determine protein requirements for production are of little value in determining the number of units of digestible crude protein required to produce one unit of milk protein.

Hills *et al.* (1922), conducting extensive investigations over a period of 13 years, found that cows produced satisfactorily on rations providing 1.26 to 1.46 times as much digestible crude protein as there was protein in milk. As the result of an extensive review of literature published by investigators working in American experiment stations, Morrison (1938, *h*) concluded that, in addition to maintenance needs, a cow required 1.25 times as much digestible crude protein as there is protein in the milk. This is confirmed by McCandlish in Scotland (1938, *c*).

Thus it seems fairly well established, that in addition to the protein allowance for maintenance, approximately 1.25 times as much digestible crude protein as there is protein in the milk is also required. Cows of high productive capacity need more than this amount, although it is claimed that when amounts greater than 1.60 times the amount of protein in the milk are fed, the production is not increased appreciably (Morrison, 1938, *i*).

In New Guinea, the possibility is that a larger and not a smaller amount of protein may be required for production, for as already mentioned, cows may not be able to utilize their feed as efficiently as they would under temperate conditions. Nevertheless, it seems reasonable to conclude that at least 1.25 times as much digestible crude protein as there is protein in the milk would be required for production purposes.

Protein available for Production.—If the amount of digestible crude protein required for maintenance is subtracted from the maximum amount of digestible crude protein which is likely to be consumed in a day, the resulting amount represents the maximum amount of digestible crude protein which is available for production thus,

For the mixed herds .. .. .. .58 — .45 lb.
= .13 lb.
For the Friesian herd .. .. .. .94 — .55 lb.
= .39 lb.

Now the average amount of protein in New Guinea milk, as given in Table II., is

For the mixed herds .. .. .. 2.81 per cent., or
.281 lb. per 10 lb. of milk.
For the Friesian herd .. .. .. 3.12 per cent., or
.312 lb. per 10 lb. of milk.

and the amounts of digestible crude protein required to produce 10 lb. of milk of the above protein content are

For the mixed herds .. .. ..

$$\frac{5 \times .281 \text{ lb.}}{4} = .351 \text{ lb.}$$

For the Friesian herd .. .. ..

$$\frac{5 \times .312 \text{ lb.}}{4} = .390 \text{ lb.}$$

so that, the maximum amount of milk which the protein intake of these cows permits them to secrete is

For the mixed herds .. .. .. $\dfrac{.13 \text{ lb.}}{.0351}$

$$= \frac{.13}{.0351 \times 2.58} \text{ quarts.}$$

$$= 1.4 \text{ quarts.}$$

For the Friesian herd .. .. .. $\dfrac{.39 \text{ lb.}}{.0390}$

$$= \frac{.39}{.0390 \times 2.58} \text{ quarts.}$$

$$= 3.9 \text{ quarts.}$$

and considering the assumptions made, these figures are in good agreement with actual fact. Actual production figures are lower than the above figures, which is to be expected, for the above figures are based on high consumption figures and on results for digestible crude protein which were determined on the most nutritious portions of the pastures which were not always available to the cows. Nevertheless, it indicates that cows in New Guinea are producing approximately as much milk as their protein, and hence, feed consumption, permits and, although there may be other factors influencing their yield, this dietary factor is paramount.

Improving Milk Production.

To improve milk production in New Guinea, it is necessary to improve the milk producing qualities of the cattle and to provide them with a good supply of a more nutritious feed.

Because of their low feed consumption, the cattle need a supply of feed even higher in nutritive value (particularly protein) than that usually fed in temperate climates. By keeping the cattle within fenced areas their grazing could be so regulated that the pastures never reached maturity. This would provide the cows with a slightly more nutritious feed but the initial expense and upkeep of wooden fences would prohibit their use on many plantations. The most satisfactory solution to the problem would be to improve the pastures by the introduction of plants of high nutritive value.

The improvement of the cattle can be brought about by the introduction of new blood or by selection, that is, by the castration of inferior males and the selection of only the best females for breeding purposes. However, it would be no use endeavouring to improve the cattle by either of these means until legumes or other plants of high nutritive value have been first established in the Territory.

Tropical Fodder Plants.

Much scientific investigation has centred around the problem of finding a suitable legume that will grow under tropical conditions. Legumes are more valuable than grasses for they are richer in protein and also carry the all-important nitrogen into the soil. Unfortunately, lucerne, subterranean clover and many other valuable legumes which grow in temperate climates cannot be grown successfully in the tropics but there is no reason to believe that there are not other plants of equal nutritive value indigenous to the tropics.

Both in the *Handbook of Philippine Agriculture* (1939, *b.*) and in the *Bulletin of the Imperial Institute* (1939), special reference has been made to *Centrosema pubescens* as a forage crop. The plant is claimed to be relished by cattle and to be high in protein. In tropical America, Hawaii, Mauritius, Madagascar and many other countries, *Leucaena glauca* has been used for many years as a fodder. It is excellent for cattle but has a depilatory effect on horses. Both these legumes have been growing in the Territory for a number of years, having been first introduced as a cover crop and shade respectively. *C. pubescens,* and to a less degree, *L. glauca*, give a slightly disagreeable odour to milk if the cows have been feeding on them up to the time of milking. This may be remedied by taking the cows off the feed for about four hours before being milked.

The *Bulletin of the Imperial Institute* (1927) also contained a brief note on the possibility of growing *Pueraria thunbergiana* as a fodder crop. This legume was introduced into New Guinea several years ago as a cover crop and is to be found growing on some plantations. Information on varieties and methods of cultivation is to be found in a paper by Calvino (1937).

Preliminary tests over the last three or four years at the Fitzroyvale Plant Introduction Station in Queensland have revealed the promising growth of the legume *Stylosanthes guyannensis*—vernacular name "Trifolio"—from Brazil. McTaggart (1937) has described its growth habit, palatability, soil and climatic requirements and strain selection. *Stylosanthes sundaica* (a) (Townsville lucerne), a small legume found in the neighbourhood of Townsville, in North Queensland, has also been receiving some attention of late as a tropical legume. Both these plants have been recently introduced into the Territory where they are doing very well. The former has a high proportion of stalk and few leaves.

Wester (1924) claims that *Vigna marina* (Silani), a perennial vine growing in the Philippines, is two and three times as nutritious as green lucerne and cowpeas respectively. This vine is of very common occurrence in the coastal districts of New Guinea, its local name being "Beach Bean".

Burkill (1935) states that in parts of Java where cattle breeding is important *Sesbania grandiflora* (Agati) is much planted. The cattle eat the leaves, which are said to increase the milk yield. A saponin is said to be present but it appears to be harmless. This plant has recently been introduced into New Guinea and is growing in the Botanic Gardens.

On several occasions, mention has been made in the *Queensland Agricultural Journal* of *Alysicarpus vaginalis* as a fodder plant. This plant is to be found growing in many parts of New Guinea where it grows to a height of about two feet.

Desmodium heterophyllum (Japanese clover) grows well in the British Solomon Islands where it is considered an excellent cattle feed. Recently, it was introduced into the Territory and it is growing profusely on a plantation near Kokopo and in the Botanic Gardens.

(a) In the *Queensland Agricultural Journal*, this plant is also referred to as *S. mucronata* and *S. procumbens*.

The leaves and stalks of Peanut (*Arachis hypogaea*), Kau Kau (*Ipomoea batatas*), Velvet Bean (*Mucuna deeringiana*), Mauritius Bean (*Mucuna aterrima*) and Cowpea (*Vigna sesquipedalis*) plants are other crops which have been suggested as good fodder crops and which are already growing in the Territory.

All these plants and, in addition, paw paw (*Carica papaya*), sweet cassava (*Manihot utilissima*) and banana (*Musa sp.*) leaves have been analysed and the results are given in Table XI. These results will now be discussed, paying particular attention to protein contents.

The analyses of the first seven plants in Table XI. show them to be good sources of protein. *Leucaena glauca* has the highest protein content but is only of value as a fodder when less than three months old, for after this, it becomes woody and ultimately grows into a tree from 20 to 30 feet high. It ratoons well, but, unless allowed to grow to maturity, does not reseed. It would be an excellent soiling crop, but could not be fed to cows within four hours of milking because of feed-taint. This is a distinct drawback.

Sesbania grandiflora resembles *Leucaena glauca* in many respects both having a pinnate leaf. Unless frequently cut it also grows into a tree about twenty feet in height. Both the young and the mature plants have comparatively few leaves and even in its young stages the plant is rather woody. The latter reason probably accounts for the fact that in Java, only the young leaves are fed to cattle. It would be a very laborious task picking sufficient leaves each day for a dairy herd. *Manihot utilissima, Alysicarpus vaginalis, Desmodium triflorum* and *Centrosema pubescens* each have approximately the same protein content. The sweet variety of *Manihot utilissima,* when very young, is promising as a fodder. It is relished by goats, although the author has no knowledge of its being fed to cattle. *A. vaginalis* and *D. triflorum* are to be found growing in many parts of the Territory but they are not eaten by either cattle or goats if there is more palatable feed available. This is probably due to their dry woody nature. *C. pubescens* is grown on many plantations as a cover crop and is relished by cattle. However, it could not form part of a mixed pasture for it is a very rampant grower and would very soon shade out grasses and other constituents of the pasture. Furthermore, it causes an obnoxious feed-taint if fed within four or five hours of milking. *Desmodium heterophyllum* comes next in protein content, and is promising as a pasture constituent in pastures growing only a few inches high, although it is not a very succulent feed. The *Stylosanthes spp.* and *Pueraria thunbergiana* are also good sources of protein although not outstanding.

These analyses give valuable information on the composition of a number of legumes and other plants which have been suggested or are being used for the feeding of cattle in tropical countries. Valuable as some of these plants are as sources of protein, they would be of little value in improving existing pastures for they would either shade out all existing grasses, need constant attention or have some other draw-back. The ideal legume would be one which has a high protein content, is succulent and palatable, grows to a height of about 2 feet (so that it will not be hidden or overgrown by tall grasses), ratoons well and reseeds itself. None of these plants possessed all or most of these qualities. Because of this, attention was next turned to certain indigenous legumes which had come under notice.

TABLE XI.—ANALYSES OF PROMISING FODDER PLANTS.

Common Name.	Scientific Name.	Water.	Crude Fibre.	Sugar and Starch.	Crude Protein.	Eth. Sol. Extract.	Ash.	Nature of Specimen.	No. of Analyses.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
..	*Leucaena glauca* ..	70	7.7	13.1	6.8	.5	1.9	Stalks and leaves ; immature plant	1
..	*Leucaena glauca* ..	64	10.6	17.7	4.5	.3	2.9	Leaves ; mature plant	1
Agata ..	*Sesbania grandiflora* ..	77	4.2	11.5	4.7	.7	2.9	Leaves ; mature plant	1
Cassava (sweet) ..	*Manihot utilissima* ..	77	8.3	7.4	4.5	.6	2.2	Leaves ; immature plant ..	1
..	*Alysicarpus vaginalis* ..	67	16.5	9.3	4.4	.3	2.5	Stalks and leaves ; plant flowering	1
Centrosema ..	*Centrosema pubescens* ..	79	8.0	6.2	4.4	.3	2.1	Stalks and leaves ; immature plant	1
Clover ..	*Desmodium triflorum* ..	71	8.9	13.4	4.4	.5	1.8	Stalks and leaves ; immature plant	1
Japanese clover ..	*Desmodium heterophyllum*	72	10.4	10.9	4.0	.5	2.2	Stalks and leaves ; immature plant	1
Townsville lucerne	*Stylosanthes sundaica* ..	81	6.7	6.7	3.3	.3	2.0	Leaves and stalks ; immature plant	1
Trifolio ..	*Stylosanthes guyannensis*	74	7.3	13.0	3.2	.2	2.3	Stalks and leaves ; immature plant	1
Trifolio ..	*Stylosanthes guyannensis*	74	7.3	13.0	3.2	.2	2.3	Stalks and leaves ; immature plant	1
..	*Pueraria thunbergiana* ..	83	6.8	4.8	3.1	.3	2.0	Stalks and leaves ; immature plant	1
Velvet bean ..	*Mucuna deeringiana* ..	82	5.5	7.0	2.9	.6	2.0	Stalks and leaves ; immature plant	1
Mauritius bean ..	*Mucana aterrima* ..	80	6.5	8.1	2.8	.5	2.1	Stalks and leaves ; immature plant	1
Beach bean ..	*Vigna marina*	89	2.2	4.6	2.5	.6	1.3	Leaves and stalks ; immature plant	1
Banana ..	*Musa* sp.	82	7.1	5.8	2.4	.4	2.3	Leaves ; immature plant ..	2
Peanut ..	*Arachis hypogaea* ..	91	2.6	2.3	2.2	.8	1.1	Stalks and leaves ; immature plant	2
Peanut ..	*Arachis hypogaea* ..	88	4.7	3.5	1.8	.6	1.4	Stalks and leaves ; mature plant ..	2
Cowpea ..	*Vigna sesquipedalis* ..	79	6.7	9.1	2.0	.4	2.8	Leaves and stalks ; immature plant	1
Kau kau ..	*Ipomoea batatas* ..	85	3.8	6.4	1.8	.5	2.5	Stalks and leaves ; immature plant	2
Paw paw ..	*Carica papaya*	80	6.3	9.1	1.1	.5	3.0	Stalks and leaves ; mature plant ..	2

There were four legumes indigenous to the Territory which, from casual observation, appeared to possess many of the above-mentioned qualities. The results of their analyses are given in Table XII. The first plant will be described in detail later. *D. polycarpum* was found growing on the Mainland and, in appearance, it greatly resembles *D. tortuosum*. *I. endecaphylla* was a small creeping plant found on New Britain and New Ireland. There was some doubt as to whether this plant was truly indigenous. *G. tenuiflora* was discovered on the Mainland, and in appearance it greatly resembles a small *Centrosema pubescens*. Seeds of these four legumes were collected and grown in experimental plots in the Botanic Gardens.

TABLE XII.—COMPOSITIONS OF PROMISING FODDER PLANTS.

Scientific Name.	Water.	Crude Fibre.	Sugar and Starch.	Crude Protein.	Eth. Sol. Extract.	Ash.	Nature of Specimen.	No. of Analyses.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
Desmondium tortuosum	72	9.9	10.3	4.8	.7	2.3	Immature ..	7
	50	15.6	28.4	2.7	.5	2.8	Full maturity	6
Indigofera endecaphylla	74	7.8	11.1	4.3	.7	2.1	Immature ..	1
	69	12.9	11.4	4.0	.6	2.1	Mature ..	1
Galactia tenuiflora ..	78	9.8	5.1	4.3	.9	2.5	Immature ..	1
	72	11.0	9.3	3.7	.7	2.7	Mature ..	1
Desmodium polycarpum	79	9.1	5.0	4.0	.7	2.2	Immature ..	1
	74	12.8	7.0	3.2	.6	2.4	Mature ..	1

Desmodium tortuosum.[*]—Of the plants mentioned in Table XII. *D. tortuosum* has the highest protein content, and was found to be superior to the other plants in several respects.

This legume was first discovered growing on New Hanover, but it has since been found on New Ireland, New Britain, and the Duke of York Islands. It is known as "koako" by the natives of the Duke of York Islands, who claim that the plant has a medicinal value. It is relished at all stages of growth by both cattle and goats.

Normally, the plant grows to a height of about 2 ft. 6 in., although plants over 5 feet were noticed growing under the shade of an embankment. It appears to grow well on almost any type of soil, and photographs 1 and 2 show the mature plants, under similar climatic conditions, growing on a heavy clay soil and on a poor light volcanic soil, respectively. If anything, the clay soil seems to favour a lower and more dense growth. When cut, the plant ratoons well, and photographs 3 and 4 were taken of plants having ratooned for the first and second time respectively. In the Botanic Gardens, there are plants which have ratooned for the fifth time and are still as healthy as ever, although after the fourth ratoon the ratio of stalk to leaf began to increase and the plants did not grow to their former heights. Photographs 5 and 6 were taken two and eight weeks, respectively, after sowing the seed. The plant generally reaches maturity in less than two months and reseeds of its own accord.

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[*] The plant was first named *D. stipulaceum*, by which name it has been referred to in certain departmental reports. Recently Mr. W. D. Francis, of the Botanic Museum and Herbarium in Brisbane, identified the plant definitely as *D. tortuosum*.

Five of the more important minor constituents of koako have been determined and the results are given in Table XIII.

TABLE XIII.—MINOR CONSTITUENTS OF KOAKO.

Constituent.	Immature Plant.	Mature Plant.
Calcium	.239 per cent.	.224 per cent.
Phosphorus	.124 per cent.	.084 per cent.
Iron	.0090 per cent.	.0082 per cent.
Carotene	180 mgms./kg.	210 mgs./kg.
Vitamin C	.33 per cent.	.24 per cent.

Calcium, phosphorus and iron were estimated by methods similar to those previously described for milk (Hutchinson, 1939, *b*). The carotene content of the plant was estimated by the method developed by Bolin and Khalapur (1938). The carotenoids of plants usually consist chiefly of β-carotene with small admixtures of α-carotene and cryptoxanthine (Fixsen and Roscoe, 1937-38, *a*, and Morton, 1940). Since .6 microgram of β-carotene has a vitamin A potency of approximately 1 international unit a rough conversion of carotene into international units of vitamin A could be made by multiplying the carotene content in micrograms by 1.6. Vitamin C was estimated in an acqueous extract by titration with 2 : 6 dichlorphenolindophenol after the removal of colouring and reducing substances with mercuric acetate and hydrogen sulphide.

It is interesting to compare the results obtained for immature koako with those obtained by different workers for young lucerne, the "king of all fodders".

TABLE XIV.—COMPOSITIONS OF KOAKO AND LUCERNE.

Constituent.	Koako.	Lucerne.	Reference.
Water	72 per cent.	82.4 per cent.	Fox and Wilson (—)
Crude protein	4.8 per cent.	6.2 per cent.	Fox and Wilson (—)
Digestible crude protein	3.8 per cent.	3.2–4.0 per cent.	Morrison (1938, *j*)
Ether Sol. Extract	.7 per cent.	.6 per cent.	Fox and Wilson (—)
Sugar and starch	10.7 per cent.	6.4 per cent.	Fox and Wilson (—)
Crude fibre	9.9 per cent.	2.4 per cent.	Fox and Wilson (—)
Ash	2.3 per cent.	2.2 per cent.	Fox and Wilson (—)
Calcium	.239 per cent.	.385 per cent.	Fox and Wilson (—)
Phosphorus	.124 per cent.	.11 per cent.	Fox and Wilson (—)
Iron	.0090 per cent.	.0083 per cent.	Fox and Wilson (—)
Carotene	180 mgs./kg.	90-400 mgms./kg.	Fixen and Rosecoe (1937–38, *b*)
Vitamin C	.33 per cent.	.07–.38 per cent.	Fixsen and Roscoe (1937–38, *b*)

Excluding crude fibre, koako contains a higher percentage of dry matter than lucerne, the excess being mostly composed of sugar and starch. The crude protein content of lucerne is higher than that of koako, but the results are not exactly comparable. Crude protein was estimated in the lucerne plant when 3–5 in. in height while the results for koako were obtained from a number of samples collected at all stages of growth up to the budding stage. From the results of Table XV., however, it is seen that the crude protein content of very young koako would be nearer 6 than 5 per cent. The ether soluble extract, the ash, phosphorus and iron contents are higher in koako than in lucerne, but calcium is considerably lower. The vitamin A and C content of koako compare very favorably with that of lucerne.

Before drawing final conclusions from this comparison, it should be remembered that the koako chosen for analysis was not any particular strain chosen for its high nutritive value, nor did it receive particular attention, such as the application of fertilizers, during its cultivation. If only the best strains of koako high in nutritive value were cultivated and the soil upon which they were growing was kept well watered and, if necessary, fertilized, koako might rank as high in nutritive value as lucerne.

Table XV. gives the crude protein content and the yield per acre of the plant at different stages of growth. Figures for yield were obtained from a small experimental plot consisting of three rows of koaka, 20 feet long and 2 feet apart, the density of planting working out at 300,000 plants per acre. The multiplication of corresponding pairs of figures gives the yield of crude protein at each stage of growth.

TABLE XV.—PROTEIN CONTENT AND YIELD PER ACRE OF KOAKO.

Stage of Growth.	Yield per acre.	Crude Protein.	Crude Protein Yield per acre.
	lb.	Per cent.	lb.
Quarter mature (6 inches) ..	1,320	4.96	65.47
Half mature (12 inches) ..	2,360	4.83	113.99
Three-quarters mature (18 inches)	3,150	4.48	141.12
Budding	3,660	3.45	126.27
Mature	3,510	2.48	87.05

If the yield of crude protein is plotted against stage of maturity, Figure 1 is obtained. From this figure, it is seen that the largest yield of crude protein for a given area is obtained by feeding the plant immediately before the budding stage. Of course, the younger the koako is grazed the higher is its nutritive value but it has less bulk in its younger stages and, in order to grow sufficient to feed a herd, it would be necessary to have extensive areas growing so that, after a certain area had been grazed, sufficient time would elapse for the plant to make fresh growth, before grazing it again. The yields per acre of first and second ratoons were found to be approximately 4,500 and 6,210 lb. respectively.

On a dry matter basis, the crude protein content of immature koako is approximately 17.1 per cent. and the digestible crude protein is 13.6 per cent., whilst the crude protein content of young New Guinea pasture is 8.5 per cent. and the digestible crude protein is 6.1 per cent. Consider a pasture consisting of 90 per cent. immature koako by weight and 10 per cent. young pasture. This pasture would have a digestible crude protein content of 12.85 per cent. on a dry matter basis. Young koako is relished by cattle and it is reasonable to assume that, if unrestricted, a New Guinea cow weighing 710 lb. would consume approximately 9.5 lb. dry weight daily and a Friesian cow weighing 910 lb., 13.6 lb. (from

Table IX.), so that the daily protein digestion of these cows would be 1.22 and 1.75 lb. respectively. Deducting protein requirements for maintenance and computing as before, it is seen that this amount of protein would be sufficient for the daily production of nine and twelve quarts of milk per cow for the mixed and Friesian herds, respectively. In the case of the mixed herds, the figure is over six times the yield computed previously and nine times the actual yield, and in the case of the Friesian herd, it is over three times the computed yield and six times the actual yield. These figures could be further increased by the addition of concentrates to the daily ration. Because of the numerous assumptions inherent in the above calculations, the results can only be considered as rough approximations.

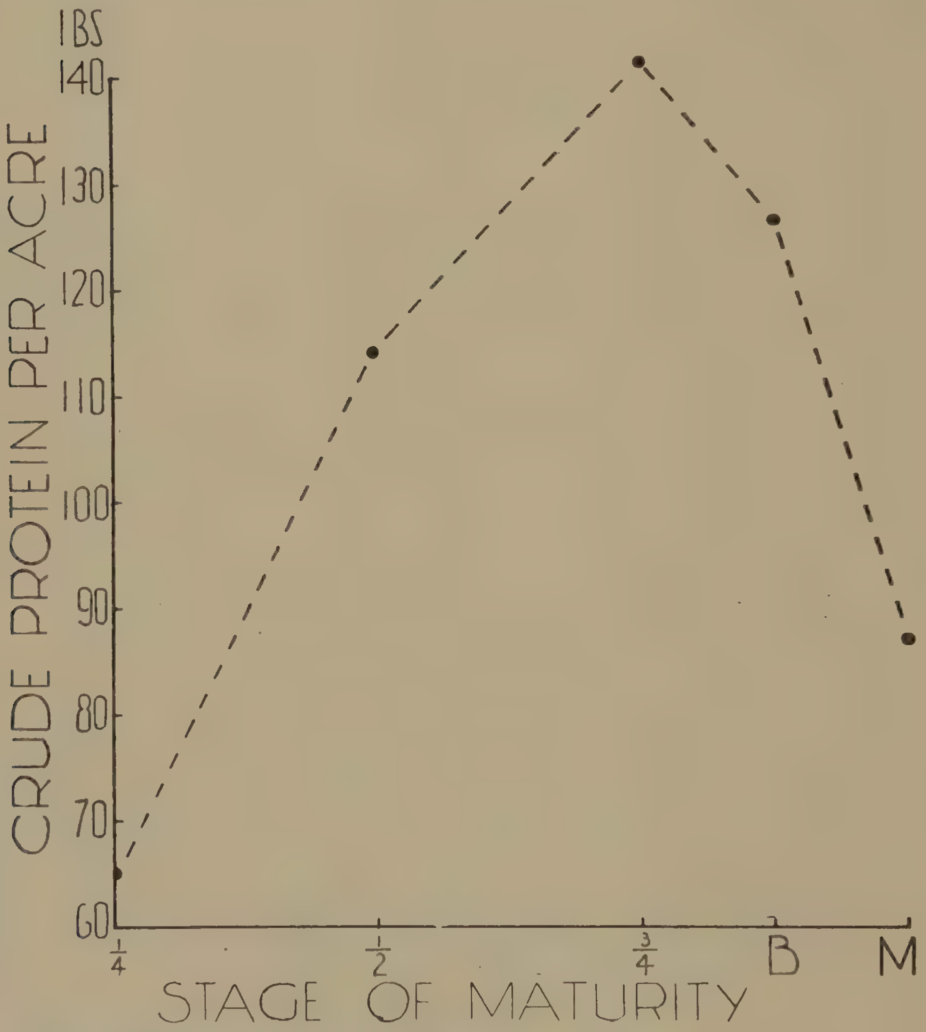

Figure 1.

It is not considered that koako is the ideal legume for New Guinea conditions, nor that it is superior to all other legumes growing in the Territory, but it possesses distinct advantages over the other legumes considered during this investigation. It is of easy cultivation, palatable, has a high protein content and would be a valuable asset to existing pastures.

As already emphasized, the milk yield of the common New Guinea cow cannot be improved by feeding alone. It is necessary that the herds should be improved by the introduction of new blood or by selection, but this improvement cannot be permanently achieved unless the cows are also given a more nutritious feed, which can be best supplied by feeding the cows on pasture containing a high proportion of a legume such as koako.

Summary.

A number of mixed milk samples collected from a Friesian and other mixed herds in the Territory of New Guinea have been analysed. The fat content was found to be high, while the solids-not-fat and specific gravities were low. The solids-not-fat portions of twenty-five milk samples were analysed and the Koestler number and "*constant moleculaire simplifiée*" computed. These results led to the conclusion that the cause of the low solids-not-fat was probably the result of inadequate feeding.

The milk yield of New Guinea cows is extremely low but it has been shown that it is as high as the protein consumption of the cows permits. To arrive at this conclusion, a number of pastures were analysed for digestible crude protein and the weight and daily feed consumption of a number of cows determined.

Numerous fodder crops have been analysed and the results discussed, paying particular attention to protein contents. *Desmodium tortuosum*, which is indigenous to the Territory, was shown to have great possibilities as a tropical fodder crop. Its composition is compared with that of lucerne.

Acknowledgments.

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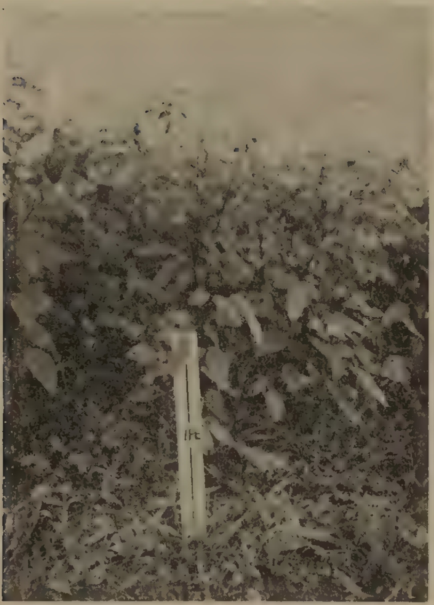


Figure 1.—*D. tortuosum* growing on heavy clay soil.

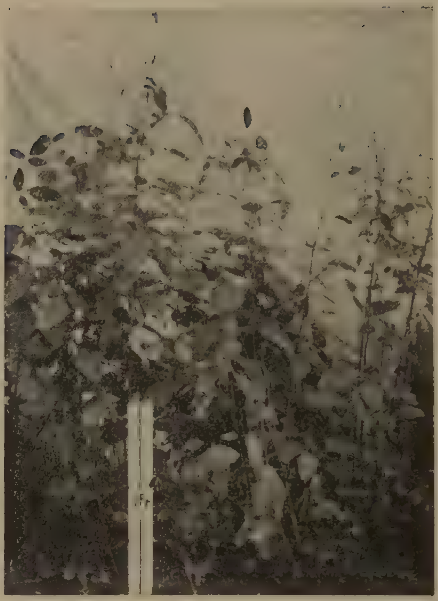


Figure 2.—*D. tortuosum* growing on light volcanic soil.

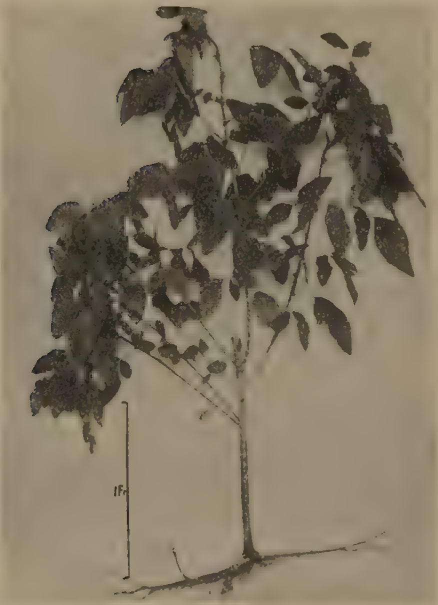


Figure 3.—*D. tortuosum*, first ratoon.

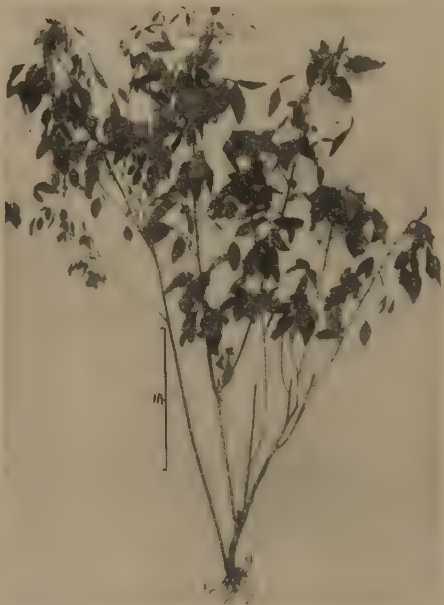


Figure 4.—*D. tortuosum*, second ratoon.

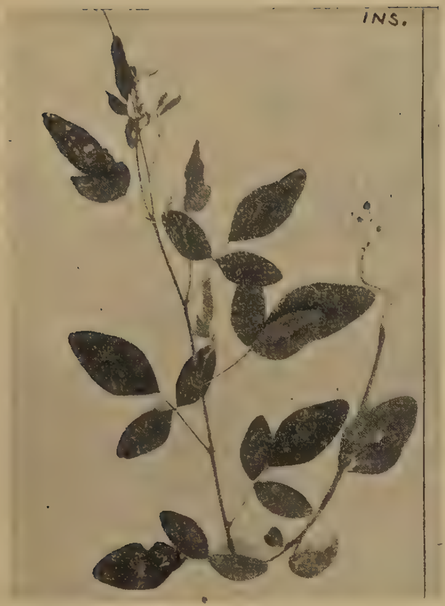


Figure 5.—Mature *D. tortuosum*, eight weeks old.

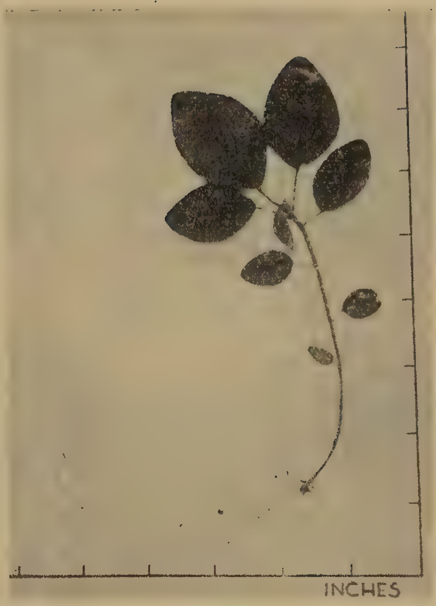


Figure 6.—Young *D. tortuosum*, two weeks old.

A herd of typical New Guinea cattle.

A pure-bred Friesian herd in New Guinea.

(Photographs by Chee Hoi Meen.)

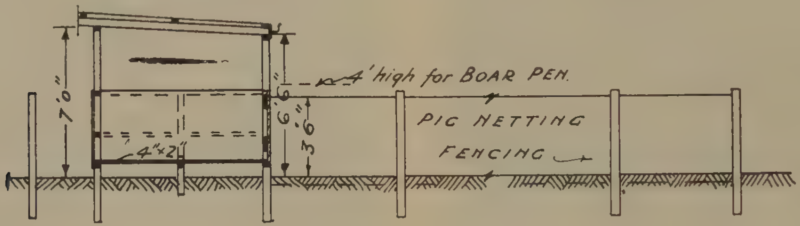
PIG NOTES.

By G. F. Gee, H.D.A.*

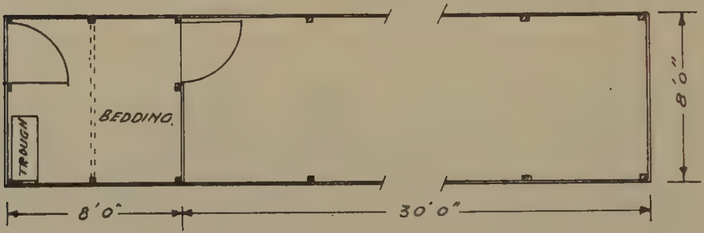
Bo Agricultural Station, New Ireland.

A Small Piggery.

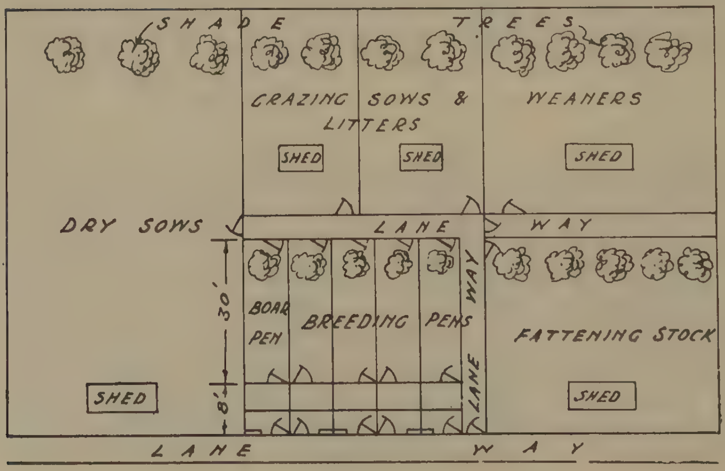
In the accompanying figure is given the layout for a small piggery suitable for New Guinea conditions. It will be seen that the plan allows for future expansion. The advantage of this layout is that the stock are moved from one


7'0"
6'6"
3'6"
4'×2"
4' high for BOAR PEN.
PIG NETTING
FENCING

SECTION


BEDDING.
TROUGH
8'0"
8'0"
30'0"

BREEDING PEN (ENLARGED)


SHADE TREES
GRAZING
SOWS & LITTERS
WEANERS
SHED
SHED
SHED
DRY SOWS
LANE WAY
30'
BOAR PEN
BREEDING PENS
WAY
LANE
FATTENING STOCK
8'
SHED
SHED
LANE WAY

LAYOUT

---

* Formerly Assistant Piggery Instructor, Hawkesbury Agricultural College.

paddock to the next, in rotation, as they grow. The dry sows are near the boar pen, which will make it easier to detect sows on heat, and they are also near at hand to be placed with the boar, when ready for service.

If the roof of the sleeping pens is made to cover a passage-way 3 feet wide in front, it will facilitate the feeding of the stock in wet weather besides giving the pens more protection from the weather. A laneway around the breeding pens allows pigs to be drafted and shifted with little trouble. Shade trees are necessary in each paddock, and a wallow would be an advantage, but this must be properly constructed. A mud hole in the paddock is worse than useless and is a source of infection for kidney worms and other parasites. The floor of the shelter sheds should be raised from ground level and should be of timber. In the breeding pens, a wooden sleeping platform of preferably 4 inches by 2 inches hardwood is necessary, as chills, paralysis and other illnesses can usually be traced to the pigs sleeping on damp ground or concrete floors. Once a young pig has received a setback from a chill, it is almost useless to attempt to fatten him, and he might just as well be killed off.

Breeds.

For all ordinary purposes, the best breed for this climate is the Berkshire, and this breed will rapidly improve local stock. If, however, an attempt is to be made to produce bacon pigs, then another breed will have to be considered, as the Berkshire is much too fat for good bacon. The Tamworth, or the Tamworth Berkshire cross, would be best if bacon is to be the main consideration, but care should be taken in the type of Tamworth boar chosen for this purpose.

Pigs from five months to a year old could be successfully introduced to this Territory with very little trouble. A boar cannot be properly selected until he is approaching six months old, and, of course, if a sow is being introduced, to farrow after her arrival, she will be almost a year old, for she would be ten months old before being mated.

Bacon Curing.

In this Territory, bacon could not be successfully cured unless refrigeration were employed. The ideal temperature is 40° – 45° F., and should never exceed 60° F. A planter may cure a little bacon and be perfectly satisfied with the result, but it would probably not keep for any time. Where refrigeration is possible, there is no reason why bacon curing should not be a successful industry in this Territory. Temperature is a most important factor in bacon curing.

A good recipe for pickling is as follows—

50	gallons clean water
160	lb. fine salt
16	lb. brown sugar
16	lb. saltpetre
1½	lb. all spice (ground)

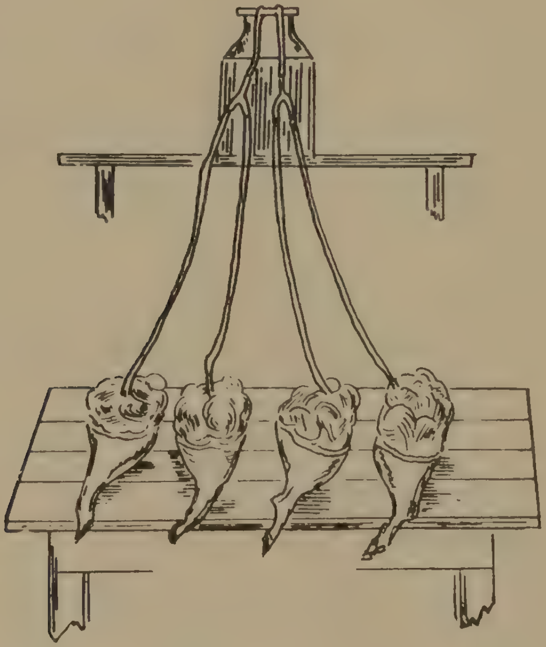
This is sufficient for about 700 lb. of meat. The procedure is as follows:— Boil water, then add salt, sugar and saltpetre. The allspice, which has been tied in a calico bag, is allowed to float in the mixture. This is boiled for one hour, and any frothy matter rising to the surface is skimmed off. The solution is then allowed to cool to room temperature before using. Each piece of meat is now pumped with the pickling solution which has been made up to 100 per cent. solution by the addition of more salt. This density is taken with a salinometer. Too much pressure should not be used during pumping, for it tears the meat. The pickle is pumped along the bone into the synovial sacs and pockets. The meat is now placed in the pickling solution and, if necessary, clean pieces of hardwood are used to keep it well covered. This method of pickling requires a needle and pump, but if these are not available a good system, as outlined in the *Handbook of Philippine Agriculture,* is as follows:—

"One or two days before killing, prepare the following ingredients for every 100 kilograms of meat to be cured.

Common salt	24.00 kgm.
Sugar	3.00
Saltpetre (potassium nitrate)	0.75
Total	27.75 kgm.

"Dissolve the above mixture in clean water to make 100 liters of solution (brine). This may be sterilized by boiling. After straining, let it stand to cool and to allow the precipitate to settle down. The precipitate is discarded by decanting. If only four legs weighing 20 kilograms are to be cured, 20 per cent. of the above formula is sufficient.

"Secure a glass tubing, with one end drawn to a fine point. Insert the pointed end into the artery of each leg.



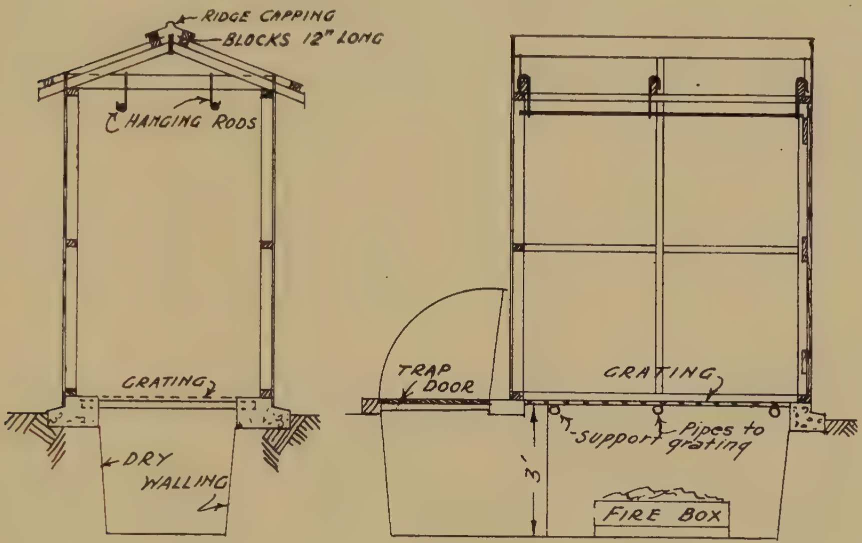
"For each leg weighing 5 kilograms, use a jar containing 5 liters of brine. The brine is siphoned into the leg by means of a rubber tubing, and allowed to flow into the leg for 18 to 24 hours. During the first two or three hours, the flow should be at high pressure to dilate the arteries and to detect any leakage, which is stopped by clamping or ligating. High pressure is obtained by placing the jar high (see illustration).

"The next day the rubber tubing is disconnected. A quantity of the curing ingredients, undissolved, is gently rubbed against the surface of the leg. The meat should be covered with a box to keep out the flies and the light. More of the curing mixture is again applied on the third day. The leg is turned over every other day.

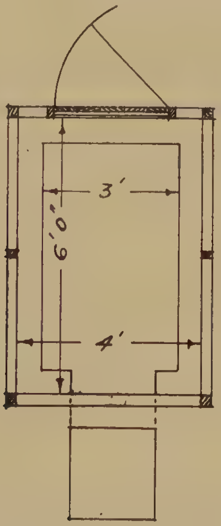
"On the sixth day, any excess salt is washed off carefully. The leg in the smokehouse is hung to drip.

"Drying and smoking is started on the seventh day. A fire is built on the floor of the smokehouse, and smoking is continued for a week or until the ham has assumed the colour and firmness desired."

Sketch Plan of Smokehouse.


RIDGE CAPPING
BLOCKS 12" LONG
HANGING RODS
GRATING
DRY WALLING
TRAP DOOR
GRATING
3'
Support
Pipes to grating
FIRE BOX

CROSS SECTION LONGITUDINAL SECTION



PLAN

Where only one or two pigs are being smoked at a time, an old 600 or 800-gallon galvanized tank makes a good smokehouse. The top of the tank is cut out, and battens, on which the meat is placed, are put across the top. A hardwood sawdust fire, about three inches deep, is made in the bottom of the tank, and the whole covered with bags or a tarpaulin. Direct heat should be prevented from reaching any meat that may be hanging over the fire, by placing a piece of galvanized iron over the fire on loose columns of bricks. If direct heat reaches the bacon, the fat will melt, and with it go part of the flavour of the meat. The smoke-room temperature should never be more than 90° F.

If something more elaborate than the tank is desired for a smoke-room, then a room about 4 feet by 6 feet, built over a 3-ft. pit and extending outside the building, with a trap-door fitted, is recommended. A ventilator is fitted to the trap-door to control combustion. This type of smoke-room is shown in the accompanying plan.

NOTES ON THE PREPARATION OF "GAPLEK" FROM CASSAVA (TAPIOCA) ROOTS.

Great success has attended the use of "Gaplek" as a partial substitute for rice in the Netherland East Indies, and the following information on the method adopted in Java for its preparation from cassava (tapioca) roots has been supplied by the Director of Commerce at Buitenzorg.

The roots of the tapioca are first pared and then split lengthwise into four parts, which are again cut into three or four pieces, 3, 4 or 5 inches long and 1½ to 2 inches thick, according to the size of the roots. These pieces are dried in a natural way, i.e., by exposing them for five or six days or longer, if necessary, to the sun and, as they contain a large percentage of water, the loss in weight is considerable. Three tons of fresh roots are necessary to obtain one ton of the dried product.

When required for food the Gaplek is converted into flour. Two and a half katies (1 katie = 1⅓ lb.) a day are sufficient for a family of five persons. Usually one gantang (= 1 gallon) of Gaplek is pounded in an ordinary rice mortar. The pulverised mass is then winnowed to separate the flour from the coarse root fibres. This flour can be used in the same way as pounded rice or maize.

For daily use as a foodstuff the flour is spread out in a tray, then kneaded with water and afterwards steamed in the same way as rice. The cooked mass is somewhat glandular and can be eaten in the same way as boiled rice, with or without vegetables and condiments.

If a certain amount of rice is available, it is advisable, instead of finishing all the rice first and afterwards using Gaplek, to mix rice and Gaplek flour in equal quantities and steam until thoroughly cooked.

AGRICULTURAL EXPORTATION IN NEW GUINEA.

The Report to the Council of the League of Nations on the Administration of the Territory of New Guinea for the year ending 30th June, 1939, has now been published. Certain portions, which are of particular interest to planters, are reproduced in this article.

In Table I., the quantities and values of all exports during 1938-39 are presented. Copra was the largest single agricultural export and Table II. shows the countries to which it was shipped.

The commencement of the present war concludes a period in the development of this Territory which began during the Great War and it is interesting to review the agricultural exports during this period. The major exports are tabulated in Table III. In addition, a shipment of coco-nut fibre was exported last year, small quantities of galip nuts were exported during 1933-34, 1935-36 and 1936-37; in 1931-32, 1932-33 and 1933-34 some Massoia bark and Massoia bark oil were exported; in 1932-33 a little coco-nut oil and in 1923-24 small quantities of cotton and cotton seeds were among the exports.

From Table III., it is seen that the major exports have been copra and cocoa, each having been exported consistently since 1915.

Figure I. shows diagrammatically the amount of cocoa exported during the period 1915-16 to 1938-39. By drawing a smooth curve through all the points plotted, a better idea of the general trend of the exportation is obtained. It is seen that the exportation slowly decreased until 1929-30 when the amount of cocoa exported was only 58 tons. After this date, exportation rose steadily, and with increasing rate of increase, and last year, the amount of cocoa exported was 56 tons greater than the year previous and nearly double what it has been for any other year.

The general trend of copra exportation is shown by the broken-line curve in Figure II. It is only this general trend which is of value, for the annual variations in exportation are more the result of an irregular shipping service, than a sudden change in production. Figure II. cannot be easily interpreted by casual observation, but it can be readily interpreted after mathematical analysis. Let y be the exportation in tons and x the number of years since the termination of the Great War (i.e. 1918-19 = 1, 1919-20 = 2, etc.) then it can be shown that,

$$y = 5.8x^3 - 316x^2 + 7300x + 5640 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

and by giving x any value from 1 to 21, a value for y is obtained which gives the approximate exportation for that year.

Differentiating (1) twice we have,

$$\frac{dy}{dx} = 17.4x^2 - 632x + 7300 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

and

$$\frac{d^2y}{dx^2} = 34.8x - 632 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

For any value of x, $\frac{dy}{dx}$ is equal to the slope of the curve of the corresponding point or, in other words, the rate of exportation at that point. When $\frac{d^2y}{dx^2} = 0$, that is, when $x = 18$, there is a point of inflection on the graph. This means that the portion of the curve from 1918-19 to 1935-36 is concave downwards and the rate of increase of exportation is decreasing, while from 1935-36 to 1938-39 the curve is concave upwards and the rate of increase of exportation is increasing. Now, if in equation (2), x is given every value from 1 to 21, 21 values of $\frac{dy}{dx}$ are obtained, that is, 21 values for the rate of increase of exportation, and it is seen that these figures decrease from 6685 when $x = 1$ to 1562 when $x = 18$ and increase from 1573 when $x = 19$ to 1701 when $x = 21$. From this it is seen that the decreasing rate of increase of exportation immediately after the Great War was much greater than the present increasing rate of increase of exportation.

This decreasing rate of increase in the exportation is interpreted as being the result of a decreased rate of increase in production of earlier planted properties, particularly, the large areas planted by the Germans before the Great War.

The recent increasing rate of increase in exportation is probably due to areas coming into full bearing which were planted after the taking over of expropriated properties, the yields from these properties more than compensating for the falling off of the earlier planted properties.—*R.C.H.*

TABLE I.—TOTAL EXPORTS DURING 1938-39.

Article.	Quantity.	Value.	Article.	Quantity.	Value.
	Tons.	£			£
Copra	73,345	727,949	Shell (marine) ..	176 tons	10,560
Desiccated coconut	1,590	69,960	Trepang ..	27 tons	2,025
Copra refuse ..	114	570	Gold	400,672 oz.	2,129,263
Cocoa beans ..	235	6,580	Tortoiseshell ..	89 lb.	89
Coffee beans ..	38	843	Timber (logs) ..	1,718,916 sq. ft.	6,544
Coco-nuts ..	259	1,554	Timber (sawn) ..	31,986 sq. ft.	367
Peanuts ..	7	105			
Rubber ..	54	4,050			
Coco-nut fibre ..	38	190			
Total ..	.. ..	811,801	Total ..	.. ..	2,148,848

TABLE II.—COUNTRIES TO WHICH COPRA WAS EXPORTED DURING 1938-39.

Country.	Quantity.	Value.
	Tons.	£
United Kingdom	33,921	336,666
European ports	12,167	120,757
Australia	9,068	90,000
Sweden	8,017	79,569
Germany	3,207	31,829
Spain	2,293	22,758
China	1,478	14,669
Holland	1,255	12,456
France..	624	6,193
Denmark	600	5,955
Caroline Islands	444	4,407
Japan	271	2,690

TABLE III.—MAJOR AGRICULTURAL EXPORTS FOR THE PERIOD 1915 TO 1939.

Year.	Copra.		Copra Refuse.		Desiccated Coco-nut.		Coco-nuts.		Peanuts.		Ivory Nuts.		Cocoa Beans.		Coffee Beans.		Rubber.	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
1915–16	11,062	161,119	..	..	..	..	..	..	..	..	..	109	186	9,005	..	..	..	1,720
1916–17	18,582	267,277	..	..	..	..	..	..	..	..	..	93	..	8,664	..	..	..	5,304
1917–18	19,708	369,837	..	..	..	..	..	..	..	..	..	180	144	11,159	..	..	..	1,673
1918–19	14,886	244,314	..	..	..	..	..	..	..	..	..	333	112	8,464	..	..	..	1,196
1919–20	22,708	745,057	..	..	..	..	..	..	..	..	..	271	140	15,530	..	..	..	1,104
1920–21	23,735	644,045	..	..	..	..	..	..	..	..	..	531	133	9,105	..	..	29	2,900
1921–22	25,894	474,110	..	..	..	..	..	..	..	..	..	..	152	9,465	..	..	..	..
1922–23	32,648	619,715	..	..	..	..	..	..	..	..	17	336	83	3,734	..	..	..	..
1923–24	34,974	686,519	..	..	..	..	..	..	..	..	16	192	70	3,602	..	..	..	..
1924–25	39,151	815,938	..	..	..	..	..	..	..	..	27	312	135	6,949	..	..	..	..
1925–26	45,806	1,016,930	..	..	..	..	..	..	..	..	28	456	113	6,510	..	..	..	..
1926–27	47,613	849,852	..	..	..	..	..	..	..	..	9	152	65	3,500	..	..	..	..
1927–28	65,285	1,176,040	..	..	..	..	..	..	..	..	..	..	73	3,859	..	..	..	..
1928–29	60,435	933,769	..	..	26	1,456	..	..	..	..	17	153	72	3,816	..	..	..	..
1929–30	63,832	864,358	..	..	192	8,640	..	..	..	..	9	77	58	3,074	..	..	..	..
1930–31	62,303	716,543	..	..	941	37,640	..	..	..	..	8	75	64	3,200	..	..	..	..
1931–32	59,452	618,298	..	..	1,282	64,100	..	..	..	..	56	280	102	3,060	..	..	..	..
1932–33	59,040	543,906	191	1,876	1,335	73,452	81	567	..	..	17	131	65	2,292	..	..	..	..
1933–34	62,270	283,329	392	3,528	1,463	81,562	76	532	1	21	73	566	98	3,479	..	..	..	..
1934–35	56,251	361,413	1,112	5,282	1,611	45,080	107	321	25	467	24	186	95	3,479	5	450	..	..
1935–36	66,684	761,309	557	5,013	1,647	65,880	198	594	35	653	69	552	127	3,810	11	880	..	..
1936–37	76,409	1,231,309	443	4,430	1,632	86,930	71	710	15	225	59	767	132	6,600	51	4,100	..	..
1937–38	73,716	847,734	402	1,759	1,579	73,423	147	882	4	84	18	162	179	4,475	41	1,025	4	242
1938–39	73,345	727,949	114	570	1,590	69,960	259	1,554	7	105	..	..	235	6,580	38	843	54	4,050

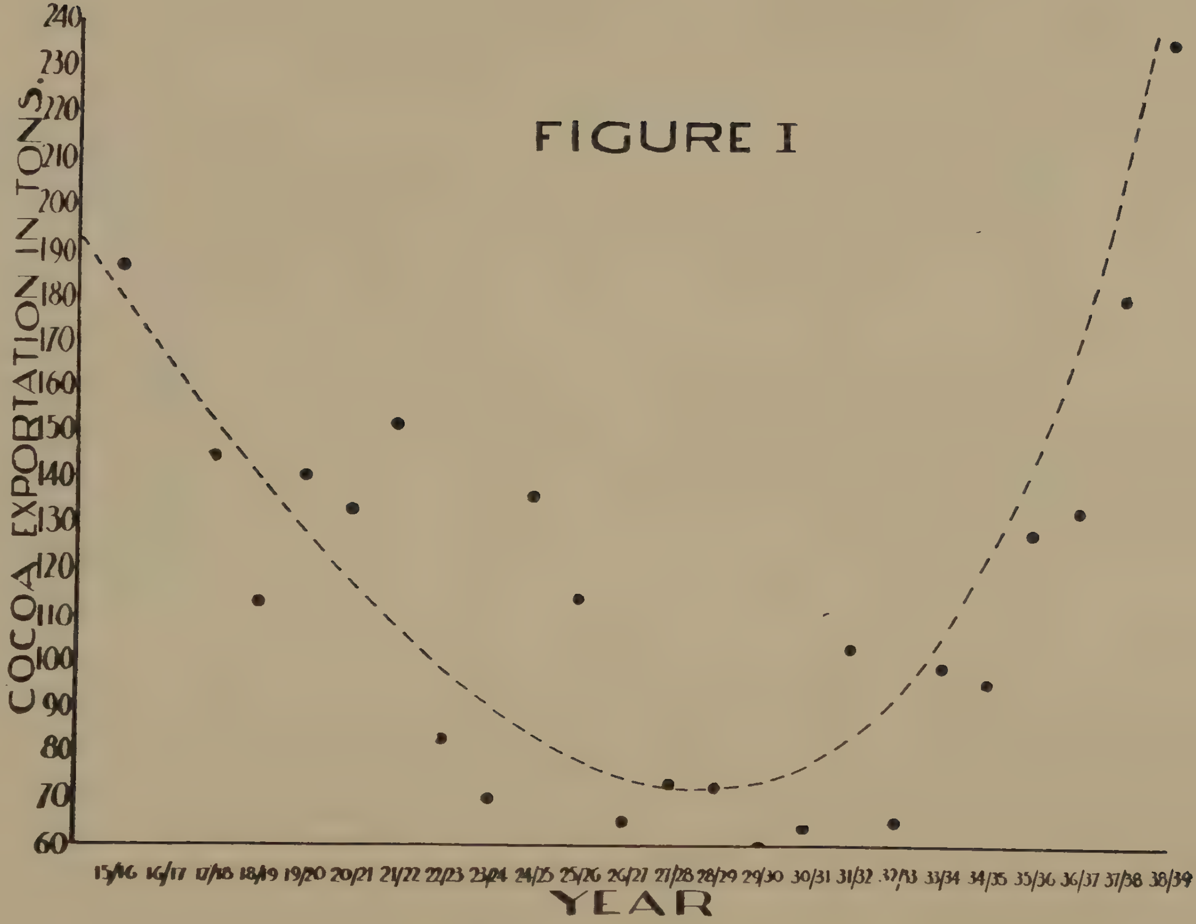


FIGURE I

COCOA EXPORTATION IN TONS.
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
15/16 16/17 17/18 18/19 19/20 20/21 21/22 22/23 23/24 24/25 25/26 26/27 27/28 28/29 29/30 30/31 31/32 32/33 33/34 34/35 35/36 36/37 37/38 38/39
YEAR

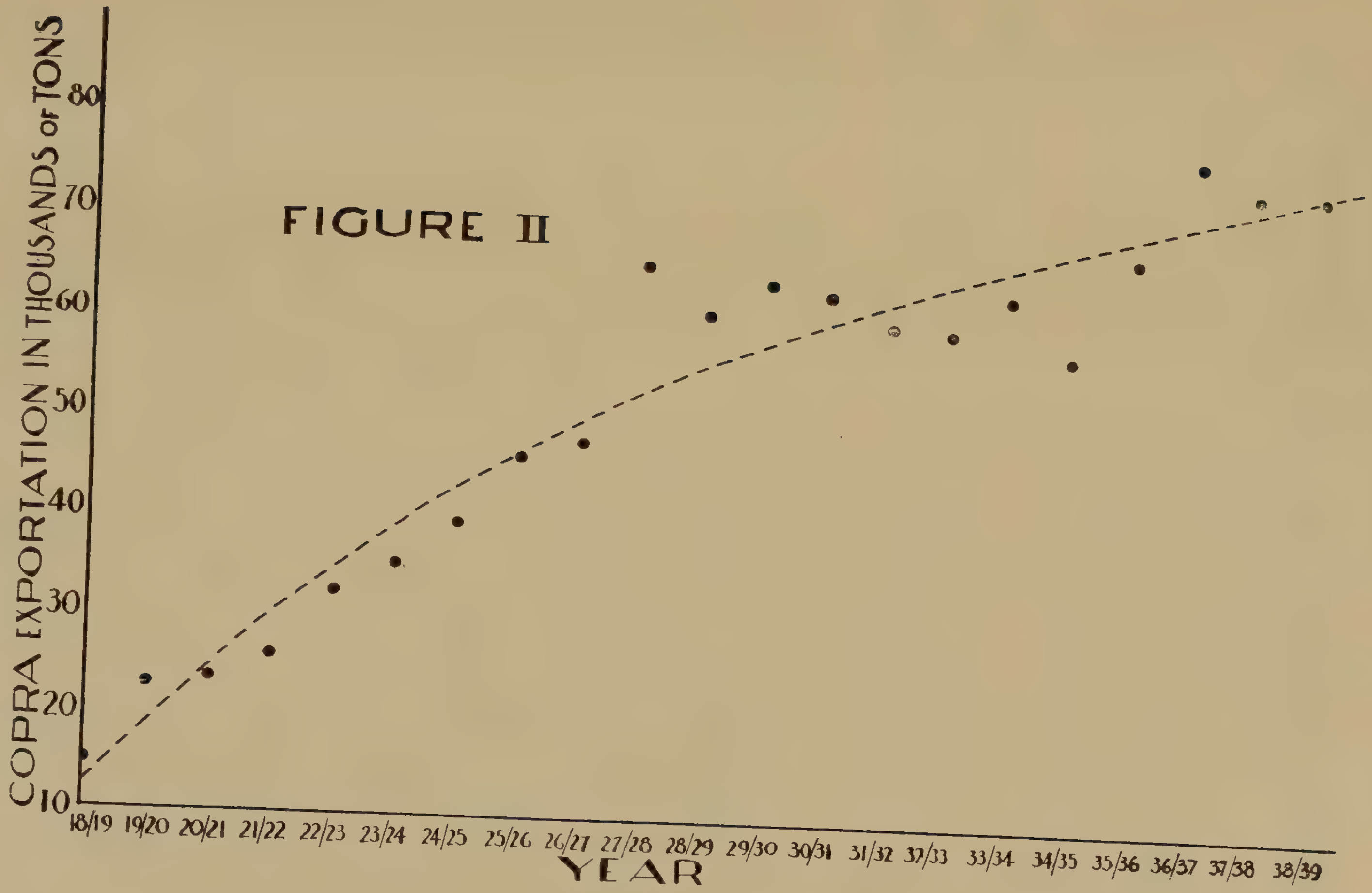


FIGURE II

COPRA EXPORTATION IN THOUSANDS of TONS
10
20
30
40
50
60
70
80
YEAR
18/19
19/20
20/21
21/22
22/23
23/24
24/25
25/26
26/27
27/28
28/29
29/30
30/31
31/32
32/33
33/34
34/35
35/36
36/37
37/38
38/39

THE CULTIVATION OF NATIVE FOOD CROPS.

By E. C. Green, *A.I.C.T.A. (Trin.), H.D.A.*

Demonstration Plantation, Keravat.

1. Taro.

Taro cultivation, especially of the native varieties, is a most important part of native food production, for taro is, by far, the most commonly cultivated of all native foods. There are two kinds of taro cultivated in this Territory—*Colocasio* spp. and *Xanthosoma* spp. The former embrace the commonly cultivated types which are generally referred to as "native taro", and the latter the Kong-kong type.

In this Territory there is a large number of varieties of native taro, probably many hundreds, and during the past five years no less than 67 varieties have been tested at the Demonstration Plantation at Keravat. As far as the writer is aware, there are only two varieties of Kong-kong taro, one a green stem and the other a blue stem, although it has been reported that a red stem variety is grown in the Talasea District.

Native Taro.

Soil.—Native taro requires a well-drained soil rich in organic matter, for it will not produce on badly drained, impoverished soils. In native gardens the site generally selected is rising ground, or hillsides, wherever possible, and wet or swampy areas are always carefully avoided.

Preparation of the Land.—Taro land should, even where virgin ground is to be planted (i.e., following clearing), be hoed to a depth of 6 to 9 inches, and in heavy soils the ground should be worked down as finely as possible. This hoeing prior to planting assists drainage and aeration, and experiments at Keravat have shown it to give a great improvement in yield.

Planting.—The land should be lined and the taro planted in rows 2 feet apart, with a space of 2 feet to 2 ft. 6 in. between the plants in the row. Either suckers or tops (i.e., the extreme top of the tuber, plus the stem) are used as planting material, and these are planted in holes 9 inches deep. The holes are quickly made by means of a pointed stick about 6 feet long and 3 inches in diameter, and as taro grows upwards and not downwards it is essential that attention be paid to the depth of the hole. Shallow holes result in the tuber being formed and developed above ground, where it does not attain normal size, becomes very susceptible to beetle attack, and in many instances rots before reaching maturity.

The sucker or top is placed in the hole and the hole covered in with soil to a depth of 3 or 4 inches, the top portion of the hole remains open and gradually fills as the crop grows. The soil covering the sucker or top should not be pressed down around the plant.

After Cultivation.—Weed and grass growth is controlled until the plants have made sufficient growth to form a complete canopy over the soil. In some districts of New Guinea it is the practice to reduce the number of suckers that are formed around the plant from time to time, but this is not necessary, and results at Keravat have not shown any significant differences in yield.

Harvesting.—The period to maturity depends on the variety, and is usually between six and nine months after planting. The plant is generally considered as having reached maturity when the leaves (except the very young ones) are dry or badly spotted, and the top of the tuber is firm and brown in colour.

The yield per acre varies according to the variety, method of cultivation and planting. Taro grown on suitable land, and planted at the proper depth, should produce at least 5 tons of edible tubers per acre.

KONG-KONG TARO.

Soil.—Soil suitable for the cultivation of native taro is also suitable for Kong-kong taro; in fact, Kong-kong taro is more intolerant of wet soil than native taro.

Preparation of the Land.—The preparation of the land is the same as for native taro.

Planting.—Kong-kong taro should be planted in rows four feet apart, with the plants spaced four feet apart in the rows. The planting material consists of suckers, parent stem, or sections of the parent stem containing a number of "eyes" in each section. Holes at least 9 to 12 inches deep must be made if suckers or parent stems are planted, and if cut sections of the parent stem are used, then the holes should be no more than 4 inches deep, otherwise the sections rot.

Large, deep holes are necessary for Kong-kong taro cultivation, because the edible portion of the plant comprises the suckers, which are produced in radial formation around the parent stem. When cut sections are planted in the shallow holes it is necessary to "hill up" the crop before the formation of the suckers.

After Cultivation.—Grass and weed growth must be controlled until the plants have formed a canopy, which is usually about two months after planting in the case of suckers and parent stems, and some four months after planting cut sections. Where cut sections have been used for planting, hilling up is carried out in the fourth or fifth month.

Harvesting.—Kong-kong taro is ready for harvest about nine months after planting, in the case of suckers or parent stems, and twelve months after the planting of cut sections. However, it is not necessary, as in the case of native taro, to harvest Kong-kong immediately it is mature; in fact, higher yields are generally obtained between twelve and fifteen months, and even as high as eighteen months after planting.

There are two methods of harvesting, the whole plant can be removed from the ground and the edible suckers taken from the parent stem, or the soil can be removed from around the parent in order to expose the suckers which are harvested, and the soil hilled up again around the parent. This latter method of harvest cannot be recommended for general practice, as Kong-kong taro, like all other roots crops, is a heavy feeder, and to grow two crops in succession on the one area of land would materially affect the soil for future crops; further, experiments at Keravat have shown that this second or ratoon crop is much smaller than the main crop.

Kong-kong taro is a heavy producer, recorded yields of more than 15 tons per acre have been obtained on many occasions at Keravat, and an average of 10 tons per acre has been obtained during the past four years, In comparing Native taro and Kong-kong taro, it might be stated that Kong-kong taro yields more than native taro, does not deteriorate if allowed to remain in the ground for months after maturity, is not so susceptible to beetle attack, and after removal from the ground will store for at least a week longer. On the other hand, native taro is quicker maturing, more palatable to the native, can be used as native food continuously without the native becoming tired of it, and surplus stems and suckers are less trouble to remove and destroy.

2. Sweet Potatoes.

The sweet potato is grown throughout the tropics and also to some extent in non-tropical countries.

Soil.—Sweet potatoes need a fairly loose, well-drained soil; heavy or wet soils produce very small crops, and the tubers are of poor quality.

Preparation of the Land, Lining.—There are two methods of preparing the land for sweet potato cultivation, namely, ridges and hills. The ridging system consists of making long, continuous ridges, whilst the hill system is one in which single or individual hills are made.

It is important to note that in each method the ridges or hills must be large; low ridges or small hills produce only small crops, as the tubers do not get a chance to reach full size, their growth being stopped by the hard ground under the hills or ridges.

The ridges or hills are spaced 4–5 feet apart and made as high as possible. At a 4-5 feet spacing the ridges or hills should be about 2 feet above ground level, and by previously hoeing the land to a depth of 9 inches, the depth of loosened soil in which the crop is to be grown is about 2 ft. 9 in. The importance of a previous turning of the soil to a depth of at least 9 inches must not be forgotten, as this allows for a maximum depth of well-worked soil in which the tubers can grow and develop.

Planting Material.—The best planting material consists of runners, or slips, or "ropes", as they are called here; these runners may be described as the vine of the plant. Runners for planting should always be taken from a bearing crop, or from an area that has been dug up and in which a certain number of tubers have been allowed to remain in the soil to provide runners. The use of runners from such sources ensures that the runners are always strong and healthy.

Planting.—Having gathered the runners, or slips, or ropes, they should be cut into lengths about 2 feet long; two or three of these short cuttings are then placed together, bent in the middle, and this central elbow, containing at least two nodes or eyes to each cutting, is planted about 6 inches deep in the soil.

Where ridges are used the cuttings are spaced about 2 ft. 6 in. apart along the top of the ridge, and on each side of the ridge about 1 foot above the ground. Where hills are used the cuttings are planted at the top of the hill and in about five or six places around the sides. The reason why some cuttings are planted low down in the ridges or hills provides for a certain amount of the crop being obtained in the space between the ridges or hills.

After Cultivation.—Weed and grass control is maintained until the runners have grown and are effectively covering the ground.

Harvesting.—The period of maturity varies according to the variety, but is generally between five and seven months. A purple fleshed variety in cultivation at Keravat can be harvested at 4½ months, although if allowed to remain until 6–7 months old the yield is almost double.

Sweet potato varieties, such as "Keravat Purple" and "Keravat White", can remain in the ground up to the end of the eighth or ninth month after planting without any serious loss in yield. Soft varieties, however, like the red-skinned yellow flesh type grown in many parts of New Guinea, must be harvested soon after maturity.

After harvest the tops should be removed and burnt, also tubers or pieces of tuber which are overlooked at the time of harvest should be dug out from time to time as they germinate. The removal of the entire crop, both tubers and vines after harvest is important in the control of the sweet potato weevil. Should planting be needed from a harvested area, then only a small section sufficient for requirements should be allowed to remain.

Yields.—The main factors affecting yield are—

1. Loose friable soil.
2. Type of planting material.
3. Large ridges or hills.
4. Allowing the crops to become fully mature.

Yields at Keravat during the year 1939 average between 7–9 tons per acre, but improved methods of cultivation adopted after experimentation towards the end of 1939, have resulted in maximum yields of up to 17¾ tons per acre being obtained, and average yields of 10–12 tons. Improvement in cultivation consisted of proper spacing, use of the correct planting material, control as far as possible of the sweet potato weevil, complete control of the sweet potato caterpillar by the giant toad (*Bufo marinus*), making of large hills, and allowing the crop to reach full maturity before harvest.

After harvest, sweet potato tubers may be stored up to ten days, providing that the skin of the tuber has not been damaged.

3. Yam.

The types of yams cultivated in the Territory of New Guinea may be divided into three groups, namely—

1. Common Yam.
2. Taitu Yam.
3. Mammee Yam.

The common yam is easily recognized by the leaf which is long and pointed, and by the thick, angular stem. The tubers are of varying shapes and the skin of the tuber may be white, cream, or red, the flesh of the tuber may be white, cream, or purple.

The Taitu yam, so called in the Territory because, under this name, the type was introduced from the Trobriand Islands. The leaf of the Taitu yam is best described as "heart shaped", the stem is round and may be smooth or covered with thorns. Three varieties are in cultivation here and the tubers are so characteristic that they are easily known from both the common yam and the mammee yam. The Taitu tuber is oval or pear-shaped, the oval type is either very hairy (that is, entirely covered with a dense coarse mat of small rootlets), or has a large number of short hard spines up to ½ inch long; the pear-shaped type is most characteristic, the upper half, which corresponds to the neck, is covered with short sharp spines, whilst the lower half or bulbous portion is entirely smooth.

The mammee yam has heart-shaped leaves, round stems, which may be smooth or thorny, and in this respect resembles the Taitu yam. However, the similarity ends here. The mammee tuber is very much smaller, is smooth or covered with fine, soft, rootlets, and grows in clusters of as many as 40 small or medium-sized tubers. The flesh of the tuber may be white or purple.

Soil.—The yam requires a loose, well-drained soil containing a fairly high percentage of organic matter. If planted in heavy, wet, or badly drained soil, the parent tuber of "set" generally rots and dies before the vines have an opportunity to become established. Should favorable weather follow planting the vines become established quickly; but they die once the soil becomes too wet, and any small tubers that have formed rot away.

Preparation of the Land and Lining.—There are three methods of preparing the land for yams, namely—

1. Hills raised above the surface of the ground.
2. Deep holes in which loose surface soil has been thrown and a hill about 1 foot high built up over the hole.
3. Long ridges raised well above the surface of the ground.

Native yam cultivators usually adopt methods Nos. 1 and 2, chiefly because they grow their yams in conjunction with other food crops such as taro, bananas, ibeka, etc., and the hills or holes can be dotted around amongst the other crops. Other reasons for the use of these methods by the native are that in coral or stony country where good, deep soil is scarce, holes can be dug between the coral or rocks and a crop obtained, also in some districts the long tuber type of yam is grown and high hills or holes allow for maximum growth.

Experience at the Demonstration Plantation, Keravat, shows that when yams are grown as a sole crop, long high ridges are best. When making the ridges it is essential that they be as large and as high as possible. the land should be previously hoed to a depth of at least 9 inches, and by spacing the ridges 4 to 5 feet apart the completed ridges should be at least 2 feet above ground level with another 9 inches of tilled surface soil beneath. Thus there is about 2 ft. 9 in. of well-tilled, friable soil in which the yam can grow and develop. In districts of high rainfall, the top of the ridge should be flattened out to minimize as much as possible washing down of the soil and so lowering the height of the ridge and exposing the parent tuber or "set". This flattening out also allows for protection against heavy storms until the vines have grown and produced a protective covering.

Should single hills or hole and hill methods be used, then the hills should be made as high as possible. The hole and hill system is not recommended at any time unless the long type of yam is to be cultivated, also from the aspect of plantation native food production and cultivation, the hole and hill method is not so economic as the ridge method.

In the hill system two "sets" may be planted, and in the ridge system the "sets" are planted at intervals of 3 feet along the top of the ridge. The hills are spaced 4 feet apart from centre to centre.

Planting.—The material used for planting is known as a "set", and consists of either a section of cut tuber, or the top of the tuber, or a full tuber.

At harvest all damaged tubers are set aside for immediate consumption, whilst the undamaged tubers are stored in a well-ventilated place and allowed to "cure". During the curing process the crop should be carefully inspected and material selected for planting so that all tubers not needed for the next season's crop can be eaten.

The plant tubers are allowed to germinate, and when the shoot has reached a length of about 3 feet the tuber is ready for planting. Once the time for planting arrives these shoots are cut back until they are about 6 inches long and contain two or three nodes, and in the case of large tubers the germinated portion plus a section of the tuber is cut off and planted. The balance of the tuber can be eaten or the cut end rubbed in ashes, and the tuber returned to storage for further germination. With mammees the tubers are usually too small for cutting and are thus planted whole, whilst in the case of the Taitu yam the medium sized tubers are planted whole, and the large tubers are cut. In many of the common yam varieties, especially the "cluster" types further germination occurs when the cut yam is returned to storage; with Taitu yam, however, a second day germination does not readily occur.

The native cultivator usually retains all small tubers for planting, and when planting is carried out he uses two or three, or even more, "sets" at each planting point. This idea is quite wrong, especially in the case of mammees, Taitu yam, and "cluster" types of the common yam. Experiments during the past two years at Keravat have proved beyond doubt that small tubers produce much smaller crops than medium-sized tubers or the cut-off top section of a large tuber. Furthermore, the proportion of small and very small tubers obtained from plants raised from small "tuber sets" is far in excess of those obtained from medium or large "tuber sets".

After Cultivation.—At all time during the growth of the crop any soil washed down must be replaced to prevent exposure of the tubers.

In the case of the common yam and the Taitu yam it is essential that the crop be "staked". Once the vines have reached a length of 3 to 4 feet it is time to "stake". Cut bush timber in lengths about 6 feet long, 2 inches in diameter, and sharpen one end. Insert the stakes strongly in the ground near the base of each vine, and attach long sticks parallel to the ground and about 5 feet above so that fence is made, and the vines as they grow are able to trail up the stakes and along the central stick.

A series of experiments conducted at Keravat showed that with mammees, the extra yield obtained from staked plants was so small that staking was uneconomic, on the other hand, "staked" Taitu yam showed an increased yield of more than 30 per cent.

The hills and ridges, also the spaces between, must be kept free of grass and weed growth.

Harvesting.—The period of maturity varies according to the type from nine to eleven months, and the crop is ready for harvest when the leaves turn brown and drop off or are covered with brown spots and the bottom of the tuber has become hard.

Recently recorded yields from bulk plantings at Keravat were 9 tons per acre from Taitu yam, and 8 tons per acre from mammees.

TOBACCO CURING.*

By F. W. Winckley,

Department of Science and Agriculture, Jamaica.

Curing.

After the plants have been cut and hung up in pairs on the rails to dry, one must wait from 35 to 50 days before the leaves and their stems are perfectly dry. The time for drying may differ greatly, as it depends on the weather. If the weather is cold and damp, it is best to keep charcoal fires burning between the several rooms in the barn to keep the air circulating as much as possible. A damp, clammy atmosphere in a barn will cause the tobacco to sweat and great care must be taken to prevent this taking place, as once sweating starts it is difficult to prevent it from going through the whole barn and so spoiling all the tobacco. If one has sunny days, it is best to hang the affected rails out in the sun for a few hours to check the sweating. On fine days, the barn should be open to air as much as possible during the day, so that it is best to have shutters made at either end of the barn to allow of their being opened and ensuring a good current of air going through the barn. After cutting the green tobacco and hanging it on the rails, it is sometimes worth while putting the rails outside in the sun for a short time, or in a place out in the open with not too much sun for a couple of days, to allow the plants to quail properly and also to prevent sweating and to hasten on the drying process. The rails should not be left out in the rain. The idea is to get the plants as free from moisture as possible before hanging them up in the barn, thus keeping the interior of the barn as free from moisture as possible.

When the tobacco leaves are quite dry and their stems are dry right up to where they join the main plant stalk, one can start stripping. The early morning is the right time to start taking the pairs of plants from the rails. About 24 pairs to a rail 12 feet long are usual, so when taking down, string up 12 pairs together, lift off the rail and place in a cool spot on the floor of the "press," or place where the fermenting is to take place, and cover over with sacking or banana matting. That is, from each rail make two big bundles of plants. When the necessary quantity has been taken down, start making a "stick press," that is, the bundles of plants with their dried leaves still hanging to them are placed in a staple with their heads or tops towards the centre and the stalk end, by which they have been hanging, outwards. This ensures that all the leaves are inside the staple or press, and as they have been taken down in the early morning they are supple and will remain so until the stripping begins. Do not keep the plants in this press more than a night or two, but start stripping as soon as possible, as fermentation will start and it is better not to ferment the tobacco while the plant stalks are still green, otherwise the leaves soak up so much moisture that it is difficult to get them dry again. When the leaves are stripped, it is better to grade for length at once, if possible, and then make them into heads of 40 to 45 leaves. These heads should be kept covered as much as possible to keep them supple, otherwise they will dry out, and be difficult to ferment properly. When a good quantity of heads is ready, they should be stapled together in a pile (pilon) from 5 feet by 5 feet to 9 feet by 9 feet and 5 feet high. Naturally, the size of the pilon depends on the quantity. When about 3 feet high, a hollow bamboo large enough to allow a thermometer to pass easily down its centre, should be placed on the layer of tobacco in the pilon. One end of the bamboo is in the middle of the pilon, and the other end sticks out 6 inches from the side of the pilon. A straight bamboo of about 1½ inches in diameter should be used and the partition between the hollow joints should be cut out with a chisel. To do this a small opening about 3 inches long and ¾ inch wide must be made at one side of the bamboo. These openings are also necessary to allow the heat from the tobacco to reach the thermometer, which must be put down the bamboo to the centre of the pilon. It is best to tie the thermometer to a strip of bamboo which can easily be pulled up or pushed down the hollow bamboo. The bulb end of the thermometer must be nearest the centre of the pilon. Then continue stapling the tobacco on top of the bamboo until the required height of 5 feet is reached. Then insert the thermometer, and cover the pilon with sacking or matting. The fermentation will start almost the first day, and every morning the thermometer must be read and a note kept of the reading. The fermentation can go on until a temperature of 130° F. has been reached, but it must not be allowed to go higher, so if one sees that it is likely to go higher in the night, the pilon must be opened up that day and turned. All the tobacco forming the sides of the pilon, two or three layers from the top and bottom, have not had any heat, so this tobacco must be put aside and later on when rebuilding the staple or pilon, it must be put in the middle, to be sure that it gets its fair share of fermentation. Turning a pilon must be done as quickly as possible, so that as little heat as possible is lost. Pilons should be built on plank floors, so it is best to have one compartment in the barn with a wooden floor raised at least 6 inches from the ground, and also the sides should be of boards or wattle plastered with mud. The method of stapling or stacking the heads of tobacco leaves is quite simple. First start a row outside completing the full size of the pilon, then about 3 inches inside this row start another row, the heads always being outwards and the tips of the leaves inwards. When these two outside rows are completed, start stapling across with the heads pointing outwards and go on doing this, making the straight rows about 3 inches apart, until the centre of the pilon is reached. Then start at the other side doing the same thing until the whole of the first layer is complete. Start the second and succeeding layers the same way and the cross rows as well, so that the pilon is composed of so many layers of tobacco, built up to 5 feet high.

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* Reprint of Tobacco Circular No. 4, Department of Science and Agriculture, Jamaica.

Barns or Tobacco Houses.

These should be built of wooden posts with wattled sides and thatched roofs. All interior wood not coming in contact with the ground may be of softer woods, although the cross-pieces, upon which the bars or rails are to rest, must be strong, as the weight of the green plants is fairly heavy.

It has always been said that one room per acre is sufficient, but with more modern methods of cultivation and consequently better sized plants, it is safer to have two rooms to the acre, and so have plenty of room to space the rails properly and dry the tobacco more quickly. The size of a barn for one acre should be then 33 feet by 27 feet by 24 feet high at the ridge pole, and 9 feet high at the plate (i.e., outside posts). The length of 33 feet is made up as follows: 3 feet, 12 feet, 3 feet, 12 feet, 3 feet. The 3-ft. spaces are walk-ways to enable one to move freely between the rooms when moving the rails. The 12-ft. spaces are the rooms, where the tobacco is to hang. In breadth, the rooms are 27 feet with a centre walk-way of 3 feet. On every row of posts across the breadth of the barn, cross-pieces must be put up at 3-ft. intervals, upon which the bamboo rails are to hang. The ends of the barns may be thatched to within 6 feet of the ground, that is, as far as the wattling, and two or three shutters, which can easily be opened or closed as required, should be made in the side thatching. For each room 125 to 130 bamboo rails are required, so for one acre, 300 bamboo rails are more than enough. The extra rails are always handy in case of breakages and if the crop is extra large. With large-sized plants it is best to space them at 1-ft. intervals on the rails; in this case 125 rails per room are necessary and these will hold 6,000 plants. One corner must be set aside to make room for a watchman and the "press", wherein the tobacco will be stored for fermentation, as explained previously.

PRODUCER GAS UNITS.

Apart from their importance in a time of national emergency, producer gas units cost so little to run that they are considered a sound investment at all times.

The making of producer gas consists essentially in drawing air through a bed of red-hot charcoal and in the following article in this issue, a clear and simple explanation of the use of producer gas for all types of road-transport vehicles is given.

Charcoal, for the production of producer gas, is usually made by completely carbonizing pieces of hardwood. Charcoal made from coco-nut shells has not been used to any extent, although it is being tested by a prominent firm in Rabaul with very satisfactory results.

Following the article on "Producer Gas" in this issue is an article on the preparation of high-grade charcoal from coco-nut shell. Wood charcoal is prepared in a similar manner.

From exhaustive tests, carried out in New South Wales, it has been found that two very suitable producer gas units are those manufactured by the following companies, from whom full particulars may be obtained:—

Harkness and Hillier, 155 Parramatta-road, Fivedock, New South Wales, and

The Powell Gas Producers (Aust.) Ltd., 142 Parramatta-road, Camperdown, New South Wales.

In reply to recent inquiries, these units were quoted as follows:—

	£	s.	d.
The H. and H. Producer Gas Units—			
Truck unit, less sales tax	85	0	0
Trailer unit, for attachment to cars	135	0	0
Chassis trailer fitting	1	10	0
	136	10	0
The Powell Gas Producer Unit—	£	s	d.
Type A (suitable for engines up to 27 h.p. and load up to 4 tons)	85	0	0
Less fitting charges	10	0	0
	75	0	0
	£	s	d.
Type B (suitable for trucks over 27 h.p. and loads of 5 tons and over	94	0	0
Less fitting charges	10	0	0
	84	0	0

In supplying these units to New Guinea, they would be accompanied by plans and descriptive matter enabling them to be installed locally.—*R.C.H.*

PRODUCER GAS.*

Fundamentals.

The making of producer gas consists essentially of drawing a limited quantity of air through a bed of red hot fuel (coal, coke, charcoal, wood, &c.).

If a container is filled with charcoal and ignited it can be fanned to a glowing mass by supplying an abundance of air to the fuel. If now the amount of air supplied to the heated bed of charcoal is reduced, there will be a quantity of charcoal at a sufficiently high temperature to combine with oxygen readily, but for which insufficient oxygen is available. The combustion of the carbon, which is the principal element of charcoal, will be incomplete, and a gas, carbon monoxide (CO), will be formed. This gas is capable of burning to carbon dioxide (CO_2) when mixed with more air and again ignited. Consequently, if a gas producer be arranged with a limited supply of air, the hot charcoal will combine with less oxygen than it would in an ordinary open fire thus forming a combustible gas which can be burned elsewhere. Hot carbon possesses another ability; it is able to dissociate the elements of water or steam to give hydrogen and oxygen. The hydrogen remains free, but the oxygen combines with carbon to give carbon monoxide. This reaction is also used in a gas producer.

It is simplest to assume that in a gas producer the first reaction is to form carbon dioxide, which is then reduced to monoxide, but whatever the case may be the results are the same and may be set out as below.

(1) $C + O_2 \rightarrow CO_2$

(2) $CO_2 + C \rightarrow 2CO$

(3) $H_2O + C \rightarrow H_2 + CO$

C = Carbon
O = Oxygen
H = Hydrogen
CO = Carbon Monoxide
CO_2 = Carbon Dioxide
H_2O = Water

The first reaction (1) is that which normally takes place in an open fire. The second (2) and third (3) will only take place at a high temperature in the absence of oxygen, and it will be seen that the first and second could be combined as follows without altering the result.

(4) $2C + O_2 \rightarrow 2CO$.

The reaction (4) or (1) and (2) combined, gives off heat (is exothermic) and this heat is used to maintain the temperature of the fuel bed and to bring about the reaction (3) which absorbs heat (is endothermic). A balance must be set up between the heat evolved in reaction (4) and that absorbed in (3) so that the temperature of the fire does not fall, consequently the amount of steam or water admitted to a gas producer must be carefully controlled. For Australian conditions the admission of steam is considered to be very desirable as the hydrogen evolved improves the quality of the producer gas. Further, oxygen obtained from steam is not mixed with nitrogen or other diluents as in the case of atmospheric oxygen used in reaction (1), thus a greater concentration of combustible gases is developed.

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* Reprint of Pamphlet No. 4, New South Wales Forestry Commission, Division of Wood Technology.

In brief, the essentials to making producer gas are—A hot bed of fuel in a suitable container and through which a limited amount of air may be drawn together with a controlled supply of water or steam. The result will be the generation of a mixture of gases: Nitrogen, hydrogen, carbon monoxide, and a small percentage of impurities. This is the mixture known as producer gas. Such a gas, when mixed with the right proportion of air, can be exploded in an internal combustion engine in exactly the same way as an air-petrol mixture.

Quite a large number of producers have been evolved in an endeavour to obtain the best possible gas with any particular fuel. The principle is the same in every case. Designers try to procure a gas which burns with great heat (high calorific value) and then to deliver this gas to the engine, free from any tar, soot, dust or other solid matter and cooled to the temperature of the surrounding air, or lower if possible.

Producer Furnaces.

Furnaces have been constructed in a great variety of shapes and sizes. The older types were almost invariably lined with fire-brick or similar material. This lining frequently led to trouble as it was affected by vibration, and it has survived only in stationary plants. In vehicular plants it has been found possible to so arrange the air inlet and the gas outlet in the furnace that the container is protected by an envelope of charcoal which surrounds the fire and through which little or no air passes. The charcoal actually acts as an insulator for its own casing. Special precautions in design have to be made at the point where the air enters the fire, as high temperatures are invariably met at such points.

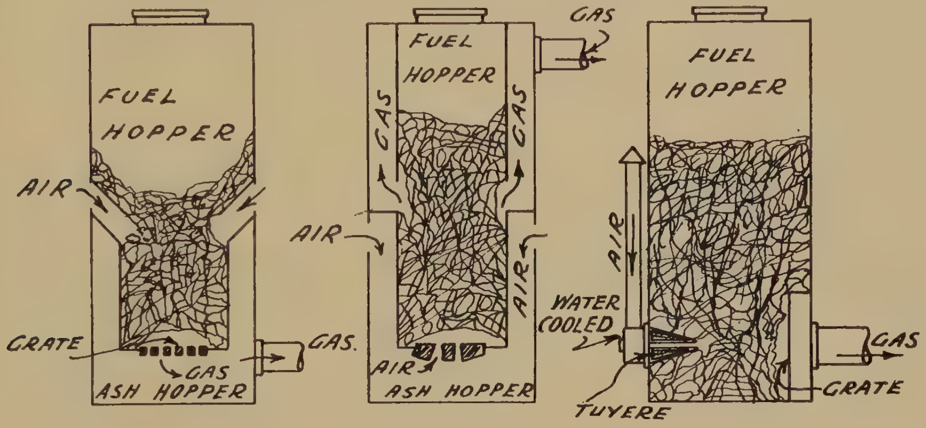
Furnaces may be divided into three types according to the direction of the draught in them, i.e., down draught, up draught, and cross draught. The first type is not normally used for charcoal plants and needs no particular explanation. In the up draught producers air is admitted at the bottom of the furnace through a grate, and considerable ingenuity has been displayed on the part of designers in making a grate which will withstand the high temperatures at this point. The furnaces are usually surrounded by a false shell which acts as an ash hopper, and the air supplied to the furnace is pre-heated in the space between the furnace and false shell. Steam is also generated in this space from a "drip feed" of water supplied to it. Gas is drawn off at the top of the furnace and passes on to the cleaning process which will be discussed later.

In the maintenance of up draught producers it is necessary to see that air is admitted through only the proper air inlet and that all doors, inspection holes, and filling holes are securely closed and sealed. The grate must be kept free of clinker as this seriously hampers the operation of the producer. Makers usually provide the necessary tools for this work, and it should be attended to at regular intervals depending on the quality of the fuel used.

In the cross draught producers the air is let into the furnace through special openings in the side of the casing. In most cases only one air inlet or tuyere is provided, and in all cases special arrangements have to be made to cool the tuyere. Some makers provide water cooling, either in conjunction with the engine-cooling system or by means of a separate water tank connected to the tuyere and operating on a thermosyphon system. Some tuyeres are cooled by the air supply to the producer, which passes round a tortuous path through the tuyere on its way into the furnace. Either steam or water is admitted with the air as it enters the furnace, and means of controlling the rate of water supply are provided.

Gas is drawn off to the cleaning system through a grate or grill on the side of the furnace opposite the tuyere, and a second grate or similar device is usually provided below the path of the gas in the furnace for the ash and clinker. As in the case of up draft producers, it is essential to see that air enters the producer only at the correct point or points and that all other openings are sealed. Clinker removal is necessary as in up draught furnaces.

Three Types of Furnaces Shown Diagrammatically.



DOWN DRAUGHT   UP DRAUGHT   CROSS DRAUGHT

Cleaning System.

When the gas leaves the furnace it carries with it particles of dust, soot, ashes, fine charcoal, etc., and it is essential that these impurities should not be allowed to reach the engine. The gas must, therefore, pass through a series of scrubbers or cleaners.

Many types of scrubber have been used by different makers, and only the most successful will be described here.

With stationary plants the practice is to use a large cylinder filled with coke or similar material as a scrubber. The gas passes from the producer upwards through the coke with which it mingles intimately and a shower of water is passed downwards through the scrubber. The coke and running water combine to clean and cool the gas very effectively.

For vehicular work the weight of the equipment is of great importance and so the coke and water scrubber has had to be discarded and replaced by dry scrubbers and dust traps. With a number of designs the gas passes straight into the dust trap and there baffles are placed to cause the heavier particles to be deposited. In another type of trap the gas passes through baffles in which the openings are shaped to impart a swirling motion to the gas, and the heavier particles are separated by centrifugal action to the outer portion of the scrubber. They then fall to the bottom of the vessel where they collect and can be removed at regular intervals.

Filters are also considerably used as gas cleaners. Pads for these filters have been made of many materials such as wood wool, metal wool, sisal, hair felt, etc., and they are usually packed into trays or cages to facilitate cleaning. In some cases the pads are soaked in oil or water, and in others they are dry. The filters must be regularly cleaned and the pads washed so that their effectiveness is not impaired. In many cases the pad material has to be teased from time to time to prevent its becoming so tightly packed as to impede the passage of the gas.

Various oil scrubbers are also used as a final stage, in the cleaning process. In some the gas actually passes through the oil, the inlet being submerged in the liquid. Another type depends on the splashing of the oil on to plates over which the gas passes. The success of such scrubbers depends on the regular changing of the oil and on maintaining the oil at the correct level.

Coolers.

It is of the greatest importance that the gas should be cooled to as low a temperature as possible before entering the engine. Adequate cooling ensures that the gas delivered to the engine is at its maximum density, giving the greatest charge (by weight) for the cylinders. Some makers have provided special coolers for this purpose in the form of radiators or nests of pipes through which the gas passes and so placed that they are cooled by the air as the vehicle moves. A separate cooler is not always necessary if the scrubbers afford ample cooling, but it can usually be classed as highly desirable. Coolers should not require any attention apart from occasional inspection to see that no soot is accumulating.

Fan or Blowers.

With some producer equipments it is usual to supply a fan or blower to be operated by hand in order to heat the furnace before starting. The fans are very similar to those used on the blacksmiths' forges and need no description. Other makers depend on the engine to supply the draught for starting the fire and start the engine on petrol. This method of starting will be dealt with later, but it should be noted here that on every producer which is not equipped with a fan provision should be made for the temporary connection of one for testing purposes. This can be done by fitting a tee-piece in the gas line just before the line reaches the mixing valve (see below). The branch of the tee should be extended to a convenient position and there closed with a blank flange. Such an arrangement would allow a fan to be connected, and in the event of starting difficulties, would enable the gas to be tested and the resistance in the gas line ascertained.

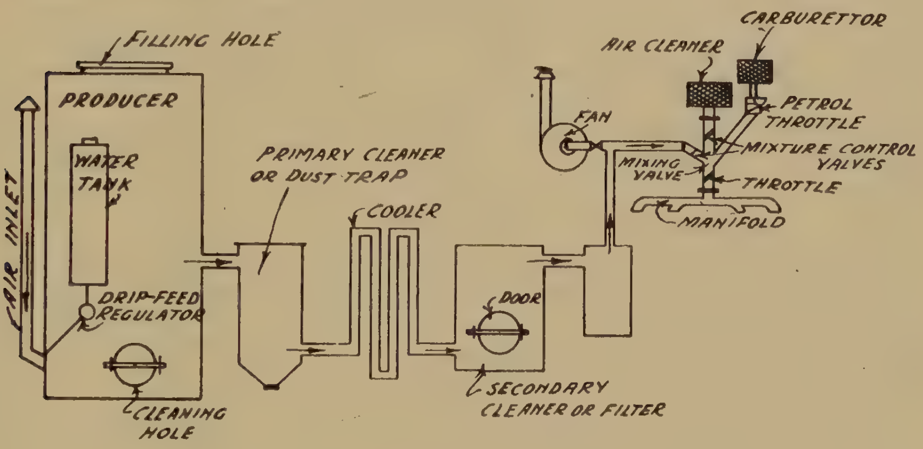
Mixing Valves.

On a producer gas engine the mixing valve takes the place of the carburettor on the petrol engine. In essence, it consists of a " Y " piece with a butterfly valve in each branch and a throttle valve in the stem. The gas line coming from the cleaning system is connected to one branch, and the other branch is coupled to the air cleaner or left open to the air. By varying the position of the two butterfly valves the ratio of gas to air can be adjusted to the best position at any time, according to the performance of the engine. It is, therefore, usual to couple the two valves together with levers and bring a control into the driver's cabin on a vehicle.

The throttle valve is of the usual type and is connected by levers to the driver's cabin in just the same way as the accelerator is connected to the throttle of the carburettor in the ordinary vehicle.

Where a converted vehicle is to be started on petrol it is also necessary to retain the entire petrol system. This means that an inlet system consisting of the induction pipe, carburettor and mixing valve have to be re-arranged so that either gas or petrol can be admitted as necessary, and although the location of the parts may vary considerably it is the equivalent of adding a third branch to the Y-piece and connecting the carburettor to this branch.

Diagram of a Typical Producer Gas Equipment Showing Sequence of Operations.


FILLING HOLE
PRODUCER
WATER TANK
AIR INLET
DRIP-FEED REGULATOR
CLEANING HOLE
PRIMARY CLEANER OR DUST TRAP
COOLER
DOOR
SECONDARY CLEANER OR FILTER
FAN
MIXING VALVE
AIR CLEANER
CARBURETTOR
PETROL THROTTLE
MIXTURE CONTROL VALVES
THROTTLE
MANIFOLD

Starting up with Blower.

In a producer plant fitted with a blower the starting-up process consists of igniting the fuel bed with a kerosene wick or similar arrangement, and then operating the blower until the producer has reached a temperature high enough to make gas. Care must be taken to see that all the valves at the mixing box are closed, so that the blower does not merely draw air back from the engine. When the gas is ready the mixing valves are set to correct positions and the engine started in exactly the same way as a petrol vehicle.

Starting on Petrol.

On vehicles without a blower the engine is started on petrol, with all mixing valves closed and the producer ignited. With the engine running at a fair speed the gas valve is opened a little to set up a draught in the furnace. The temperature of the furnace rises; gradually gas is produced and the controls are manipulated so that the engine gets more and more gas and less petrol until the petrol throttle can be closed right off and the vehicle driven on gas. The process of changing from petrol to gas requires a little practice, but after a time it should be found possible to make the change with the vehicle in motion.

Once the vehicle is settled down on gas the petrol is turned off and gas is used entirely. It should be noted that the tap for turning off the petrol should be placed in a convenient position between the petrol pump and the carburettor, and that it is advisable to have the petrol pump overhauled at the time of conversion of the vehicle.

Most users prefer to get their vehicle running on gas before they start the water feed to the producer, and this may be considered good practice, as it facilitates raising the furnace temperature.

Operation.

Once the plant is changed over to producer gas, the driving of the vehicle is in every way similar to that of a petrol vehicle. Plants have been built to give a range up to 200 miles on one filling of fuel, depending on the fuel, but an average figure of 100 miles between fuel recharging is more usual. The plant in most cases has to be stopped for refuelling, and in opening up the hot furnace some care is needed, as the hopper is likely to be filled with gas, which promptly burns. The resulting flames are too short-lived to be dangerous, but can be very unpleasant.

Maintenance.

The routine maintenance of the ordinary petrol vehicle has been reduced to an absolute minimum in recent years. A little more trouble has to be taken in attending to a producer gas vehicle, but this is only to be expected, and the success of any vehicle depends to a large extent on the care exercised by the user. The important points are set out below:—

1. The furnace must be regularly cleaned out to remove all clinker or ash.
2. The scrubbers must be emptied and inspected regularly.
3. Filter pads must be washed as required.
4. Oil scrubbers must be recharged.
5. All joints in the gas line must be kept absolutely air tight, so that air enters the system only at two points, i.e., at the air inlet to the furnace and at the mixing valve. The importance of this point cannot be over-stressed, and supplies of spare jointing material should always be on hand.
6. Supplies of clean water for cooling the tuyere and feeding to the producer must be maintained.
7. The usual maintenance required for a petrol vehicle should be given to a producer gas vehicle.

The time involved in the additional work required to maintain a producer gas vehicle will vary with the fuel quality and the capacity of the scrubbers. A reasonable estimate for a vehicle working a full day would be about ten minutes each day and an extra thirty minutes once a week. These figures should not be exceeded with plants at present available.

Choice of Fuel.

Producer gas users are advised to be careful in the selection of the fuel for their units. The idea that "anything will do" is a misguided one and often leads to trouble. Experiments indicate that any sound timber can be successfully converted into charcoal, but hardwoods are probably the best. The important points are as follows:—

1. The charcoal should be free from any unburnt portions of wood or bark.
2. The charcoal should be evenly graded with a minimum of fines. (Suggested size, $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. mesh.)
3. A charcoal with good mechanical strength and giving a metallic ring is preferable.
4. The greatest care should be taken to avoid sand or earthy impurities in the fuel, as these impurities form clinker in the furnaces. Clinker presents by far the greatest problem to be overcome in the furnace, and it can be largely avoided by using only fuel free from the above impurities.

Suitability of Vehicles.

Any petrol engine can be converted to run on producer gas. Whether the conversion will be satisfactory or not depends to a large extent on the power reserve of the engine in regard to the work performed on petrol. A definite loss of power is unavoidable, and with engines of low compression ratio, this may be as high as 40 per cent. The loss may be reduced to about 20 per cent. by increasing the compression ratio to 7 to 1, or the power loss can in some cases be completely overcome by boring out the cylinders and fitting larger pistons.

For vehicle work the power loss is often not of vital importance, as modern vehicles have fairly high compression ratios and ample power reserves. The only effects of the conversion are: A reduction in speed on hills, in acceleration, and possibly in absolute maximum speed. It follows that many vehicles could be converted to producer gas without seriously reducing their utility. On account of the necessity of maintaining a high furnace temperature, it may generally be stated that the larger the vehicle and the more uniform the load on the engine the better the results will be, as under these circumstances a more effective current of air passes through the producer.

Ignition System.

The ignition system of petrol vehicles is quite suitable for producer gas, except that arrangements must be made to increase the angle of advance of the spark when running on producer gas. Angles of advance up to 45 deg. before top dead centre have been found satisfactory, but the correct position varies with each engine and must be found by adjustment in each case.

Precautions.

All users of producer gas should remember that the gas contains carbon monoxide, which is highly poisonous and difficult to detect. There is no fear of the gas harming anyone during the normal running of a producer gas vehicle, as there is never a positive pressure in the gas line. Nevertheless, care should be exercised whenever the system is opened up for cleaning of scrubbers, &c., to avoid breathing the gas.

When an equipment is provided with a blower, the greatest care should be exercised to see that the blower is not operated in a closed room or shed, and that wherever it is operated the outlet or exhaust from the fan is not inhaled. The handle of the blower should always be removed so that the uninitiated cannot do any harm either to themselves or others.

COCO-NUT OIL AS LIQUID FUEL.

At the Vunapope Catholic Mission, situated at Kokopo in New Britain, coco-nut oil is being used as a liquid fuel. It is running a 30 h.p. H.M.G. two-stroke semi-diesel engine. The engine runs well and pulls a full load. Combustion appears to be complete, for there is no sign of smoke from the exhaust. The only trouble so far experienced was that after about fourteen hours' running, the fuel pump and injector valves began to stick and had to be taken down and cleaned.

Planters are invited to submit suggestions for the improvement of the Gazette.

Appreciation of the Gazette *can be shown by lending it to your friends.*

VEGETATIVE PROPAGATION IN TROPICAL PLANTATIONS.*

The Imperial Bureau of Horticulture and Plantation Crops, East Malling, has issued Technical Communication 13 on this subject by G. St. Clair Fielden and R. J. Garner. It deals with the vegetative propagation of some 55 plantation crops, and follows a previous communication (issued in 1936) dealing with the vegetative propagation of some 100 fruit varieties grown in the tropics and sub-tropics. The help of technical experts has been invoked for adequate treatment of such major crops as rubber, coffee, cacao, &c., while the foreign literature has been thoroughly combed for details of propagation of the less familiar, but nevertheless important, crops. One feature of the previous work, which commended it also to workers in temperate regions, is retained and considerably enlarged, namely, the section devoted to methods used in vegetative propagation. The descriptions are supported by simple, clear, line drawings of some seventeen types of graft and seven types of budding commonly used in vegetative propagation. Tropical workers will also be glad of the illustrated detail of the construction of loosely woven potting baskets which have been found so useful a substitute for pots in nursery work in the tropics. For those who wish to study originals, a list of references immediately follows the discussion on the propagation of each particular crop.

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* *Nature*, No. 3690, 20th July, 1940.

COCO-NUT SHELL CHARCOAL.[*]

By Dr. Reginald Child, B.Sc., Ph.D. (Lond.), F.I.C.

Coco-nut Research Scheme, Ceylon.

1. Introduction.

Coco-nut shell charcoal is one of the best absorbents for gases, &c., which accounts for its well-known use in gas masks and also for certain industrial operations. Before it can be used for this purpose, however, it has to undergo a technical process known as "Activation". Coco-nut shell charcoal as prepared on the estate and as exported has very little absorbing power. Purchasers of such charcoal require it to reach certain standards of quality and in particular to be free from contaminants which make the activation process more difficult. The most likely common faults of locally produced charcoal are—

(i) Too much moisture.
(ii) Not sufficiently burned, which means loss to the manufacturer of activated charcoal, as the under-burned charcoal has to be carbonized or if used causes trouble in the activating plant.
(iii) Too much sand or earthy matter.
(iv) Containing salt through using brackish water in cooling off.

Purchasers usually buy on specifications controlling these faults and typical standards are given below.

It is the purpose of this article to describe the preparation of coco-nut shell charcoal by the ordinary simple method and to show how to avoid the above and other faults so as to produce charcoal up to the usual specifications. The writer has examined a large number of locally made samples and finds that with ordinary care there is no difficulty in producing a satisfactory product.

2. Charcoal Making.

The process of making charcoal is merely the burning of shells in a limited supply of air, so that they do not burn away to ash as in a copra fire-pit, but are carbonized. The only trick of the process is to get conditions right so that the shells are carbonized to just the right degree, i.e. burned enough but not too much.

Kiln.—The kiln in which the shells are burned may be anything from a simple hole in the ground to expensive steel and brickwork patent kilns. Actually patent kilns are not in use in Ceylon. On non-friable soils, a simple pit serves well enough, but it is obviously difficult in sandy soils to prevent the charcoal becoming mixed with sand unless a brick-lined pit be used.

The shape and size of the pit may vary. The diagram[†] shows types, actually in use, of various depths. Firebricks are preferable for the lining, but ordinary local bricks stand up for a considerable time and mud mortar is said to be more satisfactory than cement. As far as shape is concerned, circular pits narrower at the top than bottom such as *A*, or bottle-shaped such as *B*, are preferable, as the firing is more easily controlled.

The shells used should be dry, clean and free from adhering fibres of husk.

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[*] Reprint from *Coco-nut Industries*, Vol. 4, No. 2, p. 77, 1940.

[†] The diagram has been adopted from that given in F. C. Cooke's *Investigations on Coco-nuts and Coco-nut Products* (1932) with the omission of the simple unbricked pit and the addition of commercial type of pit (*a*) used on everal Ceylon estates.

Procedure.—In the pit of type *A* and *B* in the diagram a fire of shells is started at the bottom of the pit; more shells are added to this until these too are well alight; then more shells and so on until the pit is completely charged, the fire being allowed to burn up before each new addition. When the full charge is well burning the fire may be damped down by sprinking water. The glowing mass is then covered to exclude air, but space is allowed for the large volume of smoke to escape.

For covering, green fronds, damp turf and soil may serve. If old corrugated sheets are available, these are used as first coverings to prevent contamination with soil, which may be placed on top.

The time taken for charging will naturally vary with the size of the pit. Some operators prefer slow charging. By this method the first fire is started and the pit covered, *A* with its circular steel cover of ¼ in. mild steel fitted with handles or *B* with galvanized sheeting. Smothered carbonization is allowed to proceed for some time before the next addition of shells, after which carbonization is again controlled by replacing the cover and so on until the pit is full. This may take, with a pit of the dimensions of *B*, up to 6 or 7 days. This slow procedure, which does not require water cooling, is said to give better uniform well-burned charcoal than the more rapid procedure described above.

It is hardly possible to give precise directions for either procedure. Some practice is required to get exactly right conditions. If the combustion is too much smothered and carbonizaiton is incomplete, a mass of woody half-burned charcoal results. If, on the other hand, the burning is not smothered enough, there is a poor yield of charcoal and it is brittle and thin.

When the pit is full the slow burning proceeds while much acid smoke is given off. During this process, the pit (as described above) is covered except for sufficient space for a smoke outlet. It is not usually possible to open the pit until the third day. When the pit is opened the mass of charcoal may catch fire and it is sometimes therefore necessary to sprinkle with water to cool off.

C is a large pit which is filled with shells which are then fired by kerosene poured down the central bamboo. The author has not seen this in operation, but does not consider that it has any particular merit.

In places with a high water table it may be necessary to use an above-ground kiln, such as *D* in diagram. This kiln is charged with shells, which are fired. When the shells are burning well, the fire hole is blocked, and air regulated by air holes at the top.

Sorting and Bagging.—The good pieces of charcoal are sorted out from the bulk; any unburned shells or under-burned pieces are put aside and used in starting the burning of the next charge.

Since accidents have occurred both on land and sea through stocks or cargoes of charcoal becoming ignited, it is now made a condition of shipment that charcoal shall be exposed freely to the air for at least 14 days before packing or bagging. It is packed in stout gunny bags holding a hundredweight (twelve to the shipping ton).

The crude charcoal contains sufficient acidic products to cause deterioration of bags on prolonged storage. This indicates that bulk storage is preferable in cases where immediate shipment is not possible. Such storage would have to be in dry godowns or warehouses. This extra handling may also cause the production of a large percentage of small pieces and dust.

3. Yield.

The weight of charcoal obtained should be just under 30 per cent. of the weight of the original shells. The weight of shells varies considerably, and in fact goes parallel with the out-turn of copra. The weight of a 1,000 shells may vary from as low as 280 lb. to as much as 400 lb. but is nearly always about a quarter of the weight of the husked nuts. Thus after a drought, when nuts are small and out-turns of copra are poor, shells will also be thin and light.

The following is a rough guide to what may be expected:—

Out-turn of copra.	Weight of 1,000 shells.	Number of shells to a ton.	Number of shells to make a ton of charcoal.
	lb.		
1,000	437½	5,120	17,650
1,100	400	5,600	19,300
1,200	365	6,140	21,200
1,300	337	6,650	23,000
1,400	312½	7,170	24,700

Twenty thousand whole shells to a ton of charcoal is a usual working average. The heaviest and thickest shells give the best charcoal.

4. Quality.

Good charcoal should be uniformly black in colour, and free from dirt due to husk. Broken edges should show a shiny black surface, and a characteristic sharp fracture. When dropped on a stone floor good pieces give a clear ring; badly burned pieces give a dull sound. Over-burned pieces are very thin and brittle; they are not favoured for inclusion in samples for export, as they easily go to dust.

Other faults of bad charcoal have been enumerated above, and buyers' specifications are based on avoiding these. Individual firms have slightly different specifications, but the following are nearly always required:—

(i) *Size.*—It is usually stipulated that not more than 5 per cent. shall pass a ¼ in. mesh sieve. Some firms have more stingent specifications indicating what percentage shall pass or be retained on a series of graduated sieves.

(ii) *Ash Content.*—A limit of 2 per cent. is usually imposed. An ash content of over 2 per cent. almost always indicates contamination with sand or soil. Clean good charcoal averages about 1.8 per cent. of ash, which is largely potash salts derived from the shells themselves. A tolerance of only 0.2 per cent., or 2 parts per thousand, is thus allowed for sand, &c., from outside. The necessity for care in seeing that no sand or soil is allowed to contaminate the charcoal is thus obvious.

Chloride Content.—One firm imposes a limit for chloride of 1.0 mg. per gm. A figure over this indicates the presence of salt, as when salt or brackish water is used for damping the fires and in cooling off. This should never be used, but only fresh water.

(iii) *Moisture.*—Different firms have different specifications for limit allowed for moisture. Five per cent. is usual, though some allow up to 10 per cent. It is not uncommon for unscrupulous local makers to damp the charcoal too much, so as to increase its weight for sale. This is easily detected and is bad business in the long run, as a prejudice is created in the buyers' minds against the particular seller practising it.

(iv.) *Volatile Matter.*—This is an arbitrary figure, and different firms have different standards. A usual limit is 15 per cent., that is, the sample when heated under certain fixed standard conditions shall not lose more than 15 per cent. of its weight. A content of volatile matter over this limit indicates under-burning, which is a fairly common fault.

5. Costs..

The price of charcoal and of shells fluctuates considerably, and it would be of little value to quote prices in this article.

In purchasing shells for charcoal making, care must be taken to have some idea of their out-turn or to buy on weight rather than by the number. As mentioned above, it may require anything from 17 to 24,000 shells to make a ton of charcoal, according to the out-turns of the nuts. Just as much care is, in fact, necessary, as in buying nuts for copra or desiccated coco-nuts, as charcoal out-turns vary in the same manner as copra and desiccated coco-nuts out-turns.

6. By-products.

Brief mention may be made of the nature of the products lost in the smoke—some 70 per cent. of the weight of the shells. If, instead of being burned in pits, shells are fired in ovens or retorts heated from outside, and the vapours given off condensed, there are obtained from 100 lb. shells, besides about 34 lb. charcoal left in the retort, some 40 lb. of a crude acid, known as pyroligneous acid, and about 5 lb. of tar. The pyroligneous acid contains 10 to 12 per cent. of acetic acid, and from the tar can be obtained carbolic acid and creosote. The working-up of these products are technical operations not suitable for small-scale working.

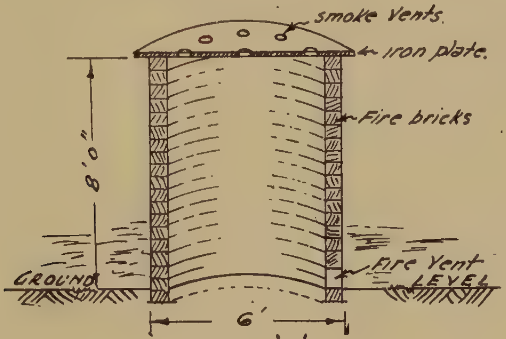
7. Conclusion.

It appears likely that the demand for charcoal will be maintained at a good level whilst war conditions continue.

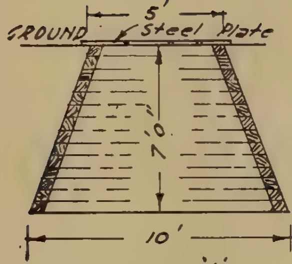
Where copra is dried in ordinary Ceylon kilns, however, not more than 300 shells are left over for charcoal making from every 1,000 nuts cured. This will doubtless give an impetus to the use of other types of kiln burning butt-ends, &c.,

and also, where practicable, to sun-drying. In very dry weather it is possible to effect considerable economy of shells by reducing the number of kiln firings and increasing the number of sun-dryings.

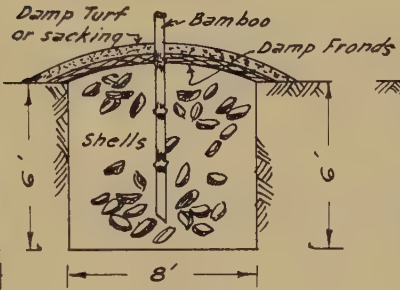
TYPES OF CHARCOAL KILNS.


smoke Vents
iron plate
Fire bricks
8'0"
Ground
Fire Vent
Level
6'

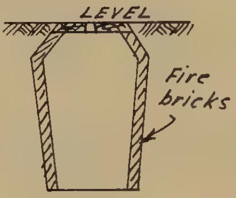
TYPE 'D'


5'
Ground
Steel Plate
6'0"
10'

TYPE 'A'


Damp Turf or sacking
Bamboo
Damp Fronds
Shells
6'
6'
8'

TYPE 'C'


Level
Fire bricks

TYPE 'B'

CHEMICAL NOTES.

A recent enquiry led to the antiscorbutic value of the juice of the common New Guinea "moolie" or lime being determined. The average figure for the analyses of the juice of five moolies from different sources was 28 milligrams of ascorbic acid (vitamin C) per 100 cubic centimetres, which is in good agreement with figures obtained for limes in temperate climates.

Approximately 2.5 milligrams of ascorbic acid per day will protect a baby from scurvy, and in case the diet of the baby does not contain this amount it is customary to supplement it with orange juice. It has been found that Australian orange juice may contain from 29 to 74 milligrams of ascorbic acid per 100 cubic centimetres, so that, three teaspoons of moolie juice are equal, in antiscorbutic value, to one teaspoon of good Australian orange juice or three teaspoons of juice from a poor orange.

The addition of sugar to the moolie juice does not lower its antiscorbutic value.

MANURIAL EXPERIMENTS FOR PLANTERS.

As a plantation is not a scientific institute, but a commercial enterprise, the planter cannot be expected to carry out experimental work, with the view of promoting scientific knowledge in general. It must be left, therefore, to the experiment station to carry out the research work necessary to solve the new problems which continually arise.

With regard to fertilizer problems, it is not necessary for the planter to undertake any research work to find out the general requirements of the plant. Experiment stations showed long ago that every plant requires certain amounts of nitrogen, phosphorus and potash, and that fertilizers which contain these elements must be supplied, if they are not already present in the soil in sufficient and available quantities.

What the experiment station cannot do, however, is to adapt the general results of its investigations to the specific conditions of different planations. This problem can only be solved by the planter himself. Within this restricted sphere, therefore, he cannot avoid some small amount of scientific work, if he wishes to apply the results of science to his own endeavours, a proceeding which is becoming more and more necessary if good results are to be obtained.

If the planter wishes to carry out practical manurial experiments, the following two conditions must be carefully observed, namely:—

(*a*) The experiment must be simple, to ensure that it be carried out in a proper manner under the difficult conditions of actual practice.

(*b*) The experiment must be laid out in such a way that the results can be relied upon, i.e., that any increase in the yield must be due to the manuring, and not to any casual outside factors.

To comply with the first condition, it is essential that the planter restrict himself when laying out the scheme of his experiment, and that he does not aspire to solve too many questions at one time. It is best to attempt to answer only one question at a time. If, for example, a planter wants information as to the elements required by his soil, he should lay out the experiment with the sole object of solving this question.

Scientific research work in, and practical experience of, more advanced countries have shown that the best dressing is one which returns to the soil all the chief elements, which are taken out of the soil by the crop; and these are nitrogen, phosphorus, potassium and possibly also calcium. If, therefore, a planter wishes to know whether it will pay him to make use of artificial fertilizers, he should lay out an experiment which will enable him to compare two plots, one of which is a check plot, receiving no manure, and the other a plot receiving a complete manure. The two plots must be equal in every respect, size, situation, aspect, composition and condition of the soil, humidity, previous treatment and manuring. The only difference between these plots ought to be that one has been fertilized. In Table 1, plot 1 remains unmanured as a check plot; plot NPK receives a complete dressing with artificial fertilizers.

TABLE 1.—PLAN OF FERTILIZER EXPERIMENT.

Plot. 1	Plot 2
Unmanured	N.P.K. Full dressing with nitrogen, phosphoric acid and potash

To calculate the profit from this manuring, the planter has only to weigh the yield from each plot and so obtain the increase due to the complete dressing. By deducting the cost of the manure applied from the value of the increased yield, he will arrive at the net profit to be gained by manuring.

The next question to be solved is, which particular plant foods are especially wanted. Such an experiment should be laid out according to Table 2. Here, to the plots 1 and 2 are added three plots, on each of which in turn one element of plant food has been omitted. Thus plot 3 receives the same amounts of nitrogen and phosphoric acid as plot 2, potash, however, being omitted. It must be here emphasized, that the dressing with nitrogen and phosphoric acid should be exactly the same on both plots. If, for example, nitrogen be given on one plot in the form of nitrate of soda, it must be given in the same form to the other plot; not in the form of nitrate of soda on one plot and in the form of sulphate of ammonia on the other. In the latter case one would not be able to say exactly whether any difference in the results of the two plots was to be attributed to the different forms in which the nitrogen was given, or to the additional potash given to the one.

TABLE 2.—WAGNER SCHEME FOR FERTILIZER EXPERIMENTS.

Plot 1	Plot 2	Plot 3
Unmanured	NPK Full dressing with nitrogen, phosphoric acid and potash	NP One-sided dressing with nitrogen and phosphoric acid without potash

Plot 4	Plot 5
PK One-sided dressing with phosphoric acid and potash without nitrogen	NK One-sided dressing with nitrogen potash without phosphoric acid

Only when this dressing of potash is the sole difference between the two plots, can one conclude that the difference in results is a consequence of the potash dressing. The same applies to plots 4 and 5, a comparison between plot 2 and 4 showing the effect of nitrogen and a comparison between plots 2 and 5 showing the effect of phosphoric acid.

As the use of nitrogen and phosphoric acid is already well and widely known, the planter will in most cases be already well informed about their necessity. The problem which remains for him to solve will be whether a complete manuring which provides also potash is more advantageous than the one-sided manuring perhaps formerly in vogue.

Such an experiment could be laid in the simplified manner of Table 3, where a comparison between O and NPK will show the effect of a complete manuring and a comparison of NPK and NP the effect due to potash alone.

Now it may be argued, that the scheme suggested here is unnecessarily complicated and that the problem could be solved in the much simpler way, unmanured against potash, i.e. by comparing a check plot receiving no fertiliser with one receiving only a potash dressing.

If we look through the literature we find many records of manurial experiments where this incorrect method has been adopted. In other cases we find experiments where planters, who were accustomed to a dressing of nitrogen alone, tried to solve the phosphoric acid and potash questions by such a scheme as comparing nitrogen with nitrogen and phosphoric acid, or nitrogen with nitrogen and potash respectively. Such trials are in no way reliable, because they ignore Liebig's law of minimum by which the development and growth of the plant is governed. Liebig proved that the development of the plant is limited by that plant food of which, in relation to the demand of the plant, the least quantity is available in the soil.

If in a certain soil, nitrogen is the weakest link, then an addition of phosphoric acid and potash, that is a strengthening of the other links, can have no effect, because growth is limited by the nitrogen which is in the minimum. In such a case a dressing of potash alone would have no effect and a trial according to one of the aforesaid schemes would lead to the wrong conclusion that potash on such a soil had no effect at all. That this is so, would be proved if we laid out an experiment according to the scheme of Table 3.

TABLE 3.—CORRECT PLAN OF A POTASH EXPERIMENT.

Plot 1	Plot 2	Plot 3
	NPK	NP
Unmanured	Full dressing with nitrogen phosphoric acid and potash	One-sided dressing with nitrogen and phosphoric acid without potash

In that method, the soil has a sufficiency of nitrogen and phosphoric acid so that the potash is enabled to show its full effect, and to show whether it be possible to augment the crop more by adding potash than is possible by one-sided manuring with nitrogen and phosphoric acid alone.

A similar mistake would be made by comparing a nitrogen plot with another plot receiving nitrogen and potash. (Table 4.) If in this case phosphoric acid be a limiting factor, allowing the combination of nitrogen and potash to act only to a certain degree, it is evident that the dressing of potash can show no effect at all. Only when a complete manure is given, i.e. one containing nitrogen, phosphoric acid and potash, can reliable and conclusive results be obtained.

TABLE 4.—FAULTY PLANS OF POTASH EXPERIMENT.

Plot 1	Plot 2
Unmanured	One-sided dressing with potash

Plot 1	Plot 2
Nitrogen alone	Nitrogen and potash

Another method of experiment which in some cases has been tried is to give to one plot say 2 cwt. of a nitrogenous manure, and 2 cwt. of a phosphatic manure; whereas to another plot is given only 1 cwt. of a nitrogenous manure, 1 cwt. of a phosphatic manure and in addition 2 cwts. of a potassic manure, presuming that the potash can replace part of the nitrogen and phosphoric acid. This idea is wrong, because each element plays a different part in the life of the plant and cannot be substituted by any other element. These elementary experiments will not only give the planter an indication as to what elements are necessary, but will also give him an idea of the quantities and in what forms they are required.

The form in which an element should be given is best determined by a special experiment. If the planter wants to know whether sulphate of ammonia or nitrate of soda be more suitable for his crop, he should compare two plots one of which has received in addition to phosphoric acid and potash, nitrogen in the form of sulphate of ammonia, whereas the other one has received the same amount of nitrogen in the form of nitrate of soda. Another point, which must be kept in mind, is that in such experiments the planter should employ only manures which have been proved by science and practice to be free of noxious substances. Sulphate of potash is to be recommended for experimental work, since this salt has no bad effect even on such very sensitive plants as tobacco and sugar cane.

Muriate of potash is also a very pure salt and may be employed for many crops. Because of its high chlorine content, however, its use is not to be recommended for sugar cane or tobacco; and even for tea or cocoa, preference should be given to the sulphate. A practice not to be recommended either, is the use of impure potash manures, e.g. crude salts, tobacco ash or sugar cane ash, because these contain accessory substances, the effect of which on tropical plants is not yet fully known but is probably harmful. In laying out manurial experiments, these impure salts should be avoided, as they may give inconclusive and misleading results.

The main source of error in manurial experiments, however, is to be found in the inequalities of the soil over the experimental area, even though one may try to choose as uniform an area as possible. To find a sufficiently large area free from these soil inequalities is impossible, so it may happen that the plot receiving a dressing of potash may be poorer than that receiving no potash and consequently, although the potash has in fact had an effect, this improvement will not be shown. In order to correct these differences and to obviate their influence on the results a certain number of control plots should be laid out which, as in a chess-board, should be evenly distributed over the whole field. If this be not possible, at least one control plot should be allowed.

TABLE 5.—EXPERIMENT WITH CONTROL PLOTS.

Plot 1 Unmanured	Plot 2 Complete manure
Plot 3 Complete manure	Plot 4 Unmanured

If the results of the unmanured plots are uniform, whereas the results of the manured plots show a variation, then with every probability this difference may be attributed to the effect of the various manurings. The greater number of control plots, however, the surer will the results be.

The experimental stations of Java, where excellent scientific work is done, even go so far as to lay out ten or twelve control plots. For practical purposes this number would be excessive, because the laying out of experiments would then be far too difficult and complicated for the planter. For practical purposes three control plots are deemed sufficient.

An exact potash experiment could therefore be laid out after the manner shown in Table 6.

TABLE 6.—POTASH EXPERIMENT WITH THREE CONTROL PLOTS.

1 O	2 NP	3 NPK
4 NPK	5 O	6 NP
7 NP	8 NPK	9 O

For field crops each plot should be about 1/40 acre (= 121 sq. yards). Then from the results of the equally manured plots, the increases resulting from the various other manurings can be calculated. If the variations between the control plots are not great, the average results of the other plots will permit of reliable conclusions. In any case, one should calculate the average yield of every kind of manuring from yields of the various control plots. For example, if plots 2, 6 and 7 gave yields of 1,000 lb., 1,020 lb. and 1,061 lb., the average of these plots (NP) would be (1,000 + 1,020 + 1,061) ÷ 3 = 1,027 lb., the differences between the average and the several different yields are respectively — 27, — 7 and + 34 lb. If we then find that plots 3, 4 and 8 had respective yields 1,179 lb., 1,201 lb. and 1,160 lb., corresponding to an average of 1,180 lb., the variations of the single plots in comparison to the average yield are 1, 21 and 20 lb. The difference between the two average yields of NP and NPK then is calculated as 153 lb. In view of the irregular distribution of the different control plots throughout the field, this difference should be put down to the potash, as it cannot be due to the variations in soil, because the variations between equally manured plots are far smaller.

For scientific purposes, another and more exact calculation of the average variation based, on the law of probability, is generally adopted, but for practical purposes our method, which is much less complicated, is sufficient.

In dealing with permanent crops, the inequalities of the soil can be eliminated by another method. In the year previous to the experiment, the plots are laid out, the soil if left unmanured and the average yields of the various plots are determined and recorded. The variation between these plots will not be very great, if care has been taken to choose a field where the soil is as even as possible all over.

In the second year, the trials of the various manures may be commenced and their effects on the yields noted. In comparing the results of the second year, the difference between the plots, as found in the first year, should be taken in account. By such a method, a truer estimate of the effect of a certain manuring may be obtained. The disadvantage is that one must wait an extra year before any results are known, and further, that the influence of the weather cannot be eliminated in this way.

Manurial experiments very often require much patience, because perennial crops do not as a rule show any beneficial results in the first year of treatment. For example, the effect of potash may be diminished by the fact that the soil in its hunger for potash may absorb the first application so greedily, that the plant benefits little. Furthermore, in contrast to nitrogen, phosphoric acid and potash will in the first year only have the effect of promoting the vigour of the plant and the growth of wood, so that only later will these elements show their effects directly upon the yield. If only for these reasons, then it is to be recommended that potash manurial experiments should always be extended over a number of years, because even where negative results are shown in the first year, planters may be sure that at the end of several years potash will prove itself a great and valuable ally in the production of the production of remunerative crops.

In spite of all the care and precautions which are taken to obtain conclusive results, it is not always possible to get precise experimental data on special questions. In such cases, the planter finds himself in a dilemma; he must either spend money on a fertilizer without being assured that his soil requires it, or he must omit some plant-food without the satisfaction of knowing that his soil does not need it. Generally the latter choice will be the more dangerous, because he then loses any chance of obtaining a crop increase which a fertilizer dressing might eventually have yielded him.

This uncertainty of experimental work has its explanation in the fact, that the planter is not dealing with a dead mechanism, but with a living organism subjected to all the incalculable influences of nature, and one which cannot be expected to react so promptly to the experimental factors, as would be the case with an experiment in the laboratory.

Experimental work in the plantation, therefore, must always be left to the personal judgment of the planter upon whose knowledge and energy depends the success of the plantation.

The planter, who is well acquainted with the nature of the soil, and the requirements of his plantation, is in a position to learn very much more from the results of experiments, even though they are not quite conclusive, than the other who lacks this knowledge and who relies only upon the figures themselves.—[*Rewritten from a pamphlet by Jacob and Coyle. R.C.H.*]

ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE, PAPUA, FOR THE YEAR 1939-40.

During the six months preceding June, 1939, the local selling price of copra rose to a value not unremunerative to the producer which led coco-nut planters to believe that the year 1939-40 might possibly be a good one. In the first half of the year, this view was further strengthened by the fact that overseas vessels called in July, November and December and lifted all the produce on hand for which the producers received a fairly satisfactory price, particularly for hot-air grade which in November and December realized £10 3s. 3d. per ton net, the gross figure being £12 7s. 6d. (London market price).

During the latter half of the year, however, and up to the time of writing, no copra carrying vessels have called and there is now little or no space for storing copra at either Port Moresby or Samarai with the result that at the moment, the product is unsaleable and the industry in a precarious position. In fact, the situation is so grave that the Commonwealth Government has intimated that some measure of assistance to planters is being considered but no indication has yet been received as to the form it will take, although it is confidently assumed that it will be sufficient to relieve the anxiety of growers, particularly those who rely on this product only.

The comparatively high market price for rubber ruling during the year stimulated planters to take up further land in new parts of the Territory suitable for its cultivation.

During the month of May, 1940, an opportunity was taken to canvass planters for the purpose of ascertaining the position of the rubber industry in the Territory, details of which are as follows:—

Number of producing plantations	23
Area under cultivation	14,494 acres
Area planted with rubber	12,964 „
Area being tapped	7,904 „

The annual production of the tappable area is estimated at 3,009,379 lb.

Taking the above figures as a guide the average yield per acre is 380 lb. but this figure is rather misleading as some plantations produce as much as 500 to 520 lb. per acre, whilst in an isolated instance the yield is given at 1,428 lb. This latter yield may appear somewhat fantastic although it is true and the explanation is that the trees on this particular area are very old and have not been tapped for many years.

At the close of the year the market price (Australian Currency) for the various grades of rubber was as follows:—

No. 1 Smoked Sheet	14.035d. per lb.
„ 2 „ „	13.248d. „ „
Clippings	13.248d. „ „
Scrap	10.666d. „ „

The cost of production and marketing, including interest on capital invested is estimated at 7.5d. per lb.

It is pleasing to note that a number of areas have been taken up in the Port Moresby District for market gardening, both for private use and commercial purposes. The Territory and more particularly Port Moresby has long felt the want of a plentiful supply of fresh fruit and vegetables and there seems to be no reason why the same cannot be successfully grown in the Laloki River District, which is close to the township, and marketed at a profit to the grower.

Agricultural exports for the year were as follows:—

Mangrove Bark	268¾ tons
Desiccated Coco-nut	1875½ ,,
Coffee Beans	77¼ ,,
Copra	6656¾ ,,
Gum	62 ,,
Rubber	1345¾ ,,
Grain	196½ Bushels
Timber	67,299 super-feet

REVIEW.

A report, "Manurial Experiments on Cocoa in Trinidad and Tobago", by F. J. Pound, Ph.D., B.Sc., Department of Agriculture, Trinidad and Tobago, has just come to hand. The report, comprising 102 pages presents results of fertilizer trials on various cocoa soils in Trinidad and Tobago. As some of these soils correspond roughly to soil types found in New Guinea, much of the information contained in this report is of interest to cocoa planters here. In the "Summary and Recommendations for Manuring existing Cocoa" it is stated—

> It has been emphasised here again that fertilising must be looked upon as an operation like pruning and draining, which may not pay off the capital expense involved in the year during which the work is done, but in which the good effects are seen long after. It is probable that, like pruning and draining, efficiency can be obtained by a small annual upkeep once the initial capital expense has been incurred.
>
> The problem at the present time is twofold: manuring to increase yields from the existing tree population, and secondly the building up of soil fertility of suitable areas in readiness for a more efficient population to come.

Upon application, interested planters will be forwarded extracts of this report if the type of soil upon which they are growing cocoa, has been dealt with therein.—*Ed.*

In a recent bulletin (*Planters' Bulletin*, No. 9, 1940), issued by the Rubber Research Institute of Malaya, information is given on the manuring of rubber trees.

Striking increases in growth and yield were obtained by the regular application of a complete manure to rubber trees of the Dunlop Malayan Estates Ltd., when they were brought into tapping ten years ago, being then seven years old. The increased yield over comparable unmanured trees was 30 per cent. or 200 lb. per acre.

The question of whether nitrogen alone would produce adequate results is still unsettled, and for the moment the inclusion of phosphate and a little potash is recommended by the Rubber Research Institute.

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THE
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DEPARTMENT OF AGRICULTURE.
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All articles submitted for publication in the *Gazette* should be typed with double spacing. Carbon copies should not be sent. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

References to articles and books should be carefully checked. In a reference the following information should be given: Initials of author, surname of author, full title of article, name of journal, volume, full date, number of the first page of article. If a reference is made to an abstract of a paper, the name of the original journal, together with that of the journal in which the abstract has appeared, should be given with full date in each instance.

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COMMUNICATIONS.

All communications should be addressed to the Editor, the *New Guinea Agricultural Gazette*, Department of Agriculture, Rabaul.

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TERRITORY OF NEW GUINEA.

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Editor, *New Guinea Agricultural Gazette* .. R. C. Hutchinson, B.Sc.

THE

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EDITORIAL NOTES.

THE local cultivation of tobacco, suitable for native use, is a subject which has been under consideration and discussion for many years. It seems agreed upon that a moderate quality tobacco can be grown in New Guinea but that the native prefers the imported product.

According to the history of the East Indies, tobacco arrived in Java and the Philippines about the year 1600. Many years before the European settlement of New Guinea, Malay and other traders visited the country and probably left tobacco seed here in the course of their trading activities. There are old Malay trade routes leading right into the Sepik hinterland. Later, the New Guinea natives used tobacco seed for trading purposes and eventually some of this seed found its way into Papua.

The natives in the neighbourhood of Madang now produce a heavy coarse-leafed tobacco which is greatly favoured for sale as local " Brus " or leaf tobacco. In most other districts, a native-grown tobacco of rather inferior quality is produced for local use.

The Germans conducted several experiments on the Gazelle Peninsula, New Ireland and Bougainville Island on the growing of tobacco. Samples of this tobacco sent to Singapore and Germany were favorably reported on. The Lutheran and Catholic Missions still grow tobacco leaf for their own use and also encourage natives to do the same. Some trade is occasionally done with small Chinese-manufactured cigars in Rabaul but such trade is of little importance.

Some of our most progressive planters have grown " Brus " tobacco for many years, both as an issue for their own labour and for sale. Such procedure has aided the cost of bringing some plantations into bearing with longer-term crops such as coco-nuts.

Several companies in Papua and New Guinea have grown tobacco suitable for native twist and, at various times, small factories have been erected with the object of producing a product which would replace the imported twist tobacco. In all cases, the natives showed definite preference for the " Beaconsfield " and " Plantation " brands of native twist introduced from America.

It would appear that this was due chiefly to the method of manufacture and the kind of dressing used, rather than to the type of leaf evolved, for the natives complained that the tobacco had a " bite ".

In recent years, most planters who have tried tobacco culture have had only a limited idea of the necessary requirements. The type of soil chosen has been unsuitable and the curing sheds have shown much to be desired. On several plantations a good mahogany-coloured leaf has been produced but seldom a very light-coloured leaf. In many cases, the production of a dark leaf, resembling imported tobacco, has been intentional. There is every indication that good pipe tobaccos of the heavier sort can be produced in New Guinea but the production of good cigarette tobacco is doubtful except, perhaps, in very limited areas.

The Department of Agriculture in New Guinea has had considerable experience with varieties of tobacco introduced from other parts of the world and prospective planters of this crop would be well advised to consult the Director or read his recent article "Brus Tobacco for Natives" in Volume 6, Number 1 of this *Gazette*. Another article which should be of interest was published in the last issue of the *Gazette*.

ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE FOR THE YEAR ENDING 30th JUNE, 1940.

DIRECTOR'S REPORT.

Owing to sick and recreation leave, the Director was absent from the Territory for four and a half months in the early part of the year under review, Mr. J. L. Froggatt acting as *locum tenens.*

The Director completed his " Outline of Policy for the Agricultural Development of the Territory of New Guinea ", and has submitted it to His Honour the Administrator. This " Outline of Policy " is based not only on a life-long experience in Papua and New Guinea, but on many discussions during the past 35 years with trained planters and scientific agricultural officers in tropical countries of both hemispheres.

During the year, Mr. R. C. Hutchinson, B.Sc., was appointed Agricultural Chemist and took up his duties in Rabaul in November, 1939. Mr. Hutchinson has also been appointed Editor of the *New Guinea Agricultural Gazette.*

The Entomologist, Mr. J. L. Froggatt, B.Sc., was absent on leave from 15th August, 1939, to 10th February, 1940.

Coco-nuts.

Copra.—For a short period in the early part of this financial year there was a slight improvement in the copra industry, but unfortunately it was only short lived. Shortly after the outbreak of war, depression set in on account of lack of shipping and matters got steadily worse. The progress of the war deprived the Territory of its European market, with the result that ultimately there was a complete collapse of the industry. During the Director's leave in Australia, he explored every possible avenue for dealing with the crisis.

On his return to the Territory he carefully investigated the question and gave the fullest consideration to the best means of meeting the emergency. He drew up the frame work of a scheme which had the approval of persons whose interests, standing and qualifications to make sound decisions in relation to this particular industry, are unquestionable.

The gist of the Director's scheme was that the Government should take control of the industry, as has been done in similar cases of emergency in other countries, buy the copra at a stated price, store the product for future sale, and if necessary erect an oil crusher. In the meantime every possible avenue could be explored to discover new uses for coco-nut oil.

For several years past, the Department of Agriculture has been carrying out experiments with copra and it has found that when such an article has been thoroughly cured, with not more than 6 per cent. moisture content, it can be kept without deterioration for eighteen months and longer, provided it is stored in a weather-proof and well-ventilated building, such as has been erected by a Rabaul firm for storage purposes. In one instance, good copra has been kept in storage for 42 months and when opened up was " bone dry " and free from insect and fungus attack.

This does not, of course, imply that inferior copra of high moisture content can be stored for any length of time. Such copra will soon deteriorate, providing ideal conditions for breeding the insect pests of stored products and should therefore not be stored with copra of good quality. It would be a comparatively simple matter for the inspectors of the Department to pass only first-class copra for storage, rejecting all else. In twelve months time, or less, an oil crushing plant could be established, and the refined oil could be kept almost indefinitely in air-tight containers.

Palm oil has been, and perhaps still is, used as fuel for diesel engines on river vessels on the Congo. It seems not unreasonable therefore to think that coco-nut oil might be put to some practical use other than soap-making, margarine, and glycerine production. Coco-nut oil, of course, can be used like palm oil as liquid fuel, but the cost of production from copra would not permit its competition with crude oil. A serious obstacle to the use of coco-nut oil as liquid fuel is that it solidifies at a temperature of 68-79° F. which precludes it for that purpose outside the tropics. In discussing this question with the Roman Catholic Bishop at Vunapope, New Britain, the Director learned that the Mission had already experimented with coco-nut oil as liquid fuel and found it so satisfactory that they had ordered another and larger oil crushing plant.

Some critics of the Director's scheme have advocated the ceasing of copra making, and recommend the indefinite storage of coco-nuts in the husk, overlooking the fact that in the humid tropics coco-nuts germinate rapidly, and even frequently sprout before falling from the parent palms. The Director of Plant Industry in the Philippines writes: "In this connexion we are not aware of any experiments conducted on the storage of coco-nuts", i.e., in the husk.

Desiccated Coco-nuts.—There are three coco-nut desiccating mills in the Territory, producing a first-class article which has a good sale on the Australian market.

Coir Fibre.—The only mill for producing coir fibre is now in operation and produces an article superior to the samples seen from Ceylon.

Fresh Coco-nuts for the Fruit Trade.—This is but a very minor industry as the infrequent shipping facilities do not permit serious competition with coco-nut-growing countries having regular and frequent shipping services to Australia.

The copra exports for the year ended 30th June, 1940, are as follow:—

Location.	Copra Submitted.	Copra Inspected.	Approximate Weight.	Unfit for Shipment. Destroyed.	Unfit for Shipment. Reconditioned.	Regraded.	Passed for Shipment Overseas.	
	Bags.	Bags.	Tons.	Bags.	Bags.	Bags.	Bags.	Tons.
Rabaul	614,680	71,424	43,985	182	13,258	14,517	606,115	42,236
Madang	186,032	18,768	13,402	139	3,744	6,208	166,384	11,883
Kavieng	94,703	12,779	6,706	106	2,137	3,926	14,163	989
Kieta	99,872	10,208	7,077	..	33	197	70,788	4,963
Manus	38,138	3,892	2,632	1	..	1,079	17,224	1,153
Travelling Inspector..	13,203	1,376	987	..	..	..	13,203	987
	1,046,628	118,447	74,789	428	19,172	25,927	887,877	62,211

Cocoa.

The area under this crop is steadily increasing, but unfortunately many planters are still planting low quality seed instead of getting only selected seed of good quality from high yielding trees. Nevertheless, there are a few plantations planted up with the best seeds from the Demonstration Plantation. One of these plantations is now coming into bearing and proves the wisdom of planting selected high quality seed. There is a certain prejudice against the use of *Tephrosia candida* as temporary shade in young cocoa plantations, although it is recognized by leading authorities as the most valuable leguminous plant in the tropics for that purpose. On account of its heavy leaf growth and branching habit it is considered of the greatest importance as a green manure plant on plantations in Ceylon, apart from its use as temporary shade for cocoa. It has proved of special value in New Guinea, particularly in the volcanic sand soils of the Gazelle Peninsula, which are very deficient in humus. It also proved even more successful than *Leucaena glauca* (a permanent shade of cocoa) in controlling "kunai" grass (*Imperata arundinacea*), the greatest weed pest of the eastern tropics. Planted in rows 7 feet 6 inches apart, the branches met in five months and smothered out the kunai leaving the ground in ideal condition for the growth of the permanent crop. In the same area *Leucaena glauca* was very patchy, some plants showing normal growth while others were stunted with few branches. Where the ground is enriched by the decomposing leaf mulch of the temporary shade, *Leucaena glauca* eventually makes ideal permanent shade for fine cocoa plants.

Coffee.

As noted in a previous annual report, *Robusta* coffee suffered a serious blow from the collapse of a plantation company, but another plantation, under very able management, is now showing indications of being a profitable proposition.

Arabian (Blue Mountain Jamaica) coffee at Aiyura Agricultural Station at 6,000 feet elevation on the mainland of New Guinea, is showing excellent growth, and there can be little doubt that it will produce just as high quality beans as in the Blue Mountains, Jamaica, from where it was originally obtained.

The Blue Mountain coffee grown at Wau continues to give heavy yields of excellent quality, and the acreage is being extended.

Rubber.

There are small areas under Para rubber (*Hevea brasiliensis*) to which the owners are now paying some attention and getting satisfactory prices. In the early days of the rubber planting industry *Hevea* seed was in such demand that the planters in New Guinea, during the German régime, were unable to get supplies, and a few large areas were planted with Assam rubber (*Ficus indica*). This species provided a marketable rubber when it was obtained only from jungle trees, but was less suited than Para for cultivation as a plantation crop, and was soon abandoned. When the prices for rubber increased, the Director was of the opinion that these areas of *Ficus* lying idle could be put to profitable use. It was realized that such trees could not produce sheet rubber but as the caoutchouc content in the latex was practically the same as in Para rubber, there seemed to be no reason why it could not be sold as scrap rubber. Tapping demonstrations were conducted and the samples of rubber obtained were favorably received by manufacturers in Australia.

The advice of the Director to tap *Ficus* areas for the production of scrap rubber was taken by the owners of the largest areas of *Ficus* in New Guinea. The result was so successful that £1,350 worth of rubber was sold in little over three months, and they have had steady sales since. Similar areas of Assam rubber are being tapped and these plants, which were considered an encumbrance, are now valuable assets. The planters have been advised not to look upon this species of rubber as a permanent crop, but to replace gradually the trees with Para (*Hevea*) trees. They have been advised to cut lanes or rentices 4 feet wide through the *Ficus*, to be lined and planted with Para rubber, the former to be gradually eliminated as the latter increase in size. By following this method the planter will have permanent Para rubber plantations with little expense, in about five years.

Tea.

The growth of these plants at Aiyura is very satisfactory, indicating the suitability of the country for tea cultivation. Tea planting is proving a highly profitable industry in the highland districts of Ceylon and in Malaya reports show that even lowland tea is proving profitable.

Cinchona.

The four species and hybrids of cinchona introduced to the Aiyura Agricultural Station on the mainland of New Guinea are showing excellent growth. The seeds were obtained from Amani Agricultural Research Station, Territory of Tanganyika, through the kindly offices of Sir Frank Stockdale, K.C.M.G., Agricultural Adviser to the Secretary of State for the Colonies. Amani was established long before the war of 1914-18 by the Germans in German East Africa (to-day Territory of Tanganyika) by obtaining cinchona from Java. Some of the plants showed an alkaloid content of 12½ per cent., but by selection and breeding, the Dutch in Java have still further improved the strain. Cinchona seed is of extreme fineness, somewhat resembling bran, minus the flour, and there are about 70,000 seeds to the ounce. It is needless to say that the germination and growth of such seeds and seedlings require very careful treatment, and the cultivation of the plants in the early stages is only suitable for trained planters.

Once the plants have reached the stage ready for transplanting, they cause little trouble, and, provided all conditions are favorable as to soil, climate, and management, cinchona can prove a profitable industry. The value of the crop per acre has been stated to be six times that of mountain-grown tea.

Rice.

This crop is maintained at Keravat and on a more extensive scale at Maprik, the head-quarters of the Inspector and Instructor in the Wewak District. Unfortunately, however, it is difficult to keep up interest in the cultivation of this valuable food plant. This should not be so as in districts where there is ample rainfall, the cultivation of rice is not heavy work.

Cassava.

This, the most valuable of all root crops in the tropics, grows practically wild in New Guinea notwithstanding its many economic uses. In Java, it is esteemed a valuable food used with, or as a substitute for, rice while other products of the plant form important items of export. As a war emergency measure, on the outbreak of war, the Director issued instructions to his staff to encourage the cultivation of cassava, as it provides starch, meal, and flour of high food value and is the most important of cultivated plants for the production of power alcohol. These instructions were issued as he anticipated that there might be a shortage of rice and petrol during the war, when the country would be in urgent need for substitutes. He also instructed the chemist to make inquiries in Australia regarding power alcohol production, but the samples of cassava did not reach him before his departure from Australia. The fears about the shortage of petrol in Australia have materialized and the Government are now discussing the possibilities of power alcohol as a liquid fuel substitute.

Minor Crops.

Such crops as peanuts, derris, maize, kaffir corn and beans of many kinds, are in cultivation to a limited extent. One planter is preparing to grow the first named on a commercial scale.

Assistance to Planters.

The Department has followed its clearly defined policy of rendering every assistance in its power to planters as follows:—

(1) By advocating the maintenance and improvement of the staple agricultural industry of the Territory.
(2) By encouraging the cultivation of new permanent crops for export, such as cocoa, rubber, *Robusta* coffee, derris at lower levels, and cinchona, pyrethrum and Arabian coffee at high elevation.
(3) By encouraging the cultivation of grain and other food crops for home and labour consumption.
(4) By encouraging planters to adopt modern methods in cultivation and production of all such crops.
(5) By the inspection of produce for marketing.
(6) By the supply of seeds and other planting material of high quality, economic crops.
(7) By controlling insect pests and diseases.

Inspectors and Instructors are allocated to specific districts and frequently inspect plantations to advise planters in agricultural practice and the control of pests. In cases where more intensive investigations are necessary, an agricultural officer is sent from the head-quarters of the Department and stays long enough in the district to see that his recommendations are carried out.

Cultural advice is given by correspondence and by visits of the Director or other technical officer. In certain cases arrangements are made with planters to carry out experiments on their plantations, under the advice of the Director.

Two planters have been carrying out such experiments with regard to shade on cocoa plantations using *Tephrosia* and *Leucaena glauca* in accordance with the advice of the Director.

Control of Pests and Disease.

Work of this nature is part of the regular routine of the Department's operations and is described in detail in annexed reports.

Distribution of Seeds and Planting Material.

These are supplied to planters at reasonable prices and gratis when supplied for experimental purposes.

Inspection of Copra.

This work has been steadily maintained and every effort has been made to see that the quality of the Territory's copra is kept at a high standard.

Avenues in Rabaul.

The avenues in Rabaul have received constant attention and are steadily recovering from the damage they sustained in the eruption of 1937. The avenue of Royal Palms (*Oreodona regia*) in Kombiu-street is now beginning to show to advantage, although there are several misses to be filled.

The Museum.

No additions of any consequence have been made to the Museum during the year, but everything has been kept in good order.

Botanic Gardens.

The Gardens have been maintained in good order during the year. Shortage of water, combined with the poor soil, which consists of volcanic sand with only a little humus, is a heavy handicap on the growth of plants. The only manure available is that formed by leaves and grass cuttings, which are placed in pits to decay.

Some years ago the Department demonstrated that an odorless hygienic manure could be prepared from all town waste by what is known as the Indore Process. This is a thoroughly scientific process established by Sir Albert Howard, Director of the Agricultural Research Institute, Indore, endorsed by the Indian Medical Service, and used in military cantonments and many towns throughout India. Eventually it was adopted by the Public Health Department on the recommendation of the Director of this Department. It proved very successful and the Botanic Gardens were greatly benefited by the application of this valuable manure. Unfortunately, the process was abandoned after the eruption of 1937, and the Botanic Gardens have ever since suffered in consequence.

Up to date all the propagation of decorative and economic plants of the Department has been done by the Botanic Gardens' nursery staff. One of the most important activities of the Botanic Gardens' staff is the vegetative propagation of plants by marcotting and grafting, some very satisfactory results having been obtained with a seedless pomelo. Many experiments have been made to propagate the very decorative plant *Monodora myristica*, but they have always failed. On the arrival of the chemist to the staff he was instructed to carry on experiments with the recently discovered method of using auxins to encourage root development. He used Hortomone A. Recently, the Chinese gardener, Ah Fat, made experiments on his own account without any root-promoting substance, and had 10 per cent. strikes, all of which are flourishing. Practically all imported seeds or plants are handled at the nursery and established before distribution to the Demonstration and other plantations. Planting material for shipment is also frequently sent to other countries, even as far as Russia, a quantity having been sent to the Institute of Applied Botany, Leningrad, for introduction to the Caucasus. A correspondence is maintained by the Department with the Royal Botanic Gardens, Kew, and other leading botanic gardens throughout the world.

Economic Section or State Plantation.

This part of the Department's activities is situated at the western end of the Botanic Gardens. The Economic Section consists of about 10 acres, three-fourths of which is sloping ground with a fall of 31 feet from the eastern boundary. In 1929 the area was laid out in blocks and planted with economic crops, particularly selected Robusta coffee and cocoa with suitable shade. The soil, being composed largely of volcanic sand and pumice, is very subject to erosion on account of its steep slope, but it was hoped this could be obviated by cover plants, and ridging each or every second row of trees if necessary. This proved to be unsatisfactory, and it was decided to terrace the area. The contours for three terraces were surveyed and the construction work was performed by the Botanic Gardens Assistant with garden labourers. The sides of the terraces were revetted with turf and, have stood up to the heaviest of tropical downpours before even the ground was able to settle properly. After manuring with leguminous plants and all the town waste available, the area was handed over to the Economic Botanist for his experimental work.

Animal Husbandry.

Sheep.—A new step in the development of the Territory was the introduction of six head of Romney Marsh ewes and one ram to the Aiyura Agricultural Station. Unfortunately, the young ram died at sea a few days after leaving Brisbane, but the ewes duly arrived at their destination. Much of the country on the Upper Ramu consists of rolling uplands covered with good grazing and the animals are thriving in their new home land. A new ram is being ordered from Australia, and there is good reason to believe that this experiment will prove the embryo of a profitable industry. Javanese or hairy sheep thrive in the lowlands of the Territory and provide good quality mutton. In fact, fresh lamb from these sheep is quite equal, if not superior, to the frozen meat imported from Australia.

Goats.—These animals are to be found on many coco-nut plantations and make a very good substitute for sheep mutton. Milking breeds of goats have been introduced to the Territory, and appear to thrive under tropical conditions.

In this Territory it is essential that they should be provided with dry shelter against rain, and have good sleeping quarters.

Cattle.—These animals thrive in the uplands of the Territory, but need care against swamp cancer in the lowlands. European breeds with a strain of Zebu blood are practically resistant to tropical stock diseases and pests. There is a pure bred herd of Friesian cattle in the neighbourhood of Rabaul kept for the local milk supply and, with due care, it is not troubled with pest or disease. One of the owner's main difficulties is to obtain suitable land close to Rabaul for grazing.

Native Agriculture.

Native coco-nut groves have been regularly inspected by the inspectors and instructors of the Department, and the owners duly instructed in the work of maintenance. The collapse of the copra industry has affected this branch of agriculture but, of course, the crisis is not such a serious matter to natives as to the European planter. The inability to sell copra means, to the native, a loss of luxuries, but to the European planter, the loss of his very livelihood.

During the last half of the year under review, there has been an increasing accumulation of fallen coco-nuts in the groves and, if this state of things continues, indefinitely, they must eventually go back to jungle. This condition has been intensified by overplanting of coco-nuts in the past, contrary to the advice of this Department, and it will be a hardship on the natives if they are compelled to maintain such groves in good order. Small groves with good ground covers of *Centrosema pubescens* will require little trouble to maintain, but unfortunately many natives have not carried out this practice. The natives have ceased attempting to sell their coco-nuts or make copra, usually only smoked, but they have taken things philosophically as they have not suffered any serious loss. When copra prices were higher, many of the more experienced natives in the Rabaul District erected hot-air driers in localities recommended by the Department and under its supervision. To these natives the losses were considerable, as the structures cost about £70 each and, in many cases, were built with borrowed money.

For some time past Inspectors and Instructors have been allocated to certain districts with head-quarters centrally situated. Thus they can be in closer contact than formerly with natives. Village gardens are inspected frequently and new crops and improved methods introduced to native agriculture. In this way the natives come to know the agricultural officer personally, and, in some districts, his influence has spread so widely that they come long journeys to visit him, for advice and to obtain planting material. This is particularly the case at Aiyura and Maprik.

In the Kieta District, native coco-nut groves are well cared for, many having good ground covers of *Centrosema* (a leguminous creeper) which assists in suppressing noxious weeds. In fact, some of these native groves are better maintained than many European plantations. This is largely due to the practical knowledge of tropical agriculture and an understanding of natives on the part of the Inspector and Instructor who was, for a long time, stationed in the same district. His work has also been of valuable assistance to other branches of the Administration, and has received the praise of the District Officer.

The native groves in the Kavieng District, New Ireland, are only visited at irregular intervals, as the Inspector and Instructor stationed there has also to act as Customs Clerk. These added duties prevent him from giving the attention required for native agriculture which suffers in consequence.

An Inspector and Instructor is now stationed at Bo, Namatanai, a sub-district of New Ireland. From this centre he will be able to devote a large part of his time to native agriculture, giving advice and instruction and distributing fresh seeds of economic plants.

An Inspector and Instructor is now stationed at the Talasea sub-district of New Britain. Large areas of native coco-nut groves have been planted up in this district, but, so far, there is nothing special upon which to report. When the Inspector and Instructor has become fully established, every effort will be made to have native agriculture organized on the same lines as in the Kieta District.

An Inspector and Instructor is now stationed at Maprik, Wewak District, at about 700 feet elevation and two days walking distance from the Sepik River. Several economic plants have been established at this centre, and the Inspector and Instructor has been in contact with many thousands of natives.

In the Madang District, an Inspector and Instructor has been stationed on the upper Ramu highlands for the past four years. His centre is at Aiyura 6,000 feet above sea level, where he has shown amazing enterprise.

The land on the Ramu Plateau consists largely of rolling downs covered with a vegetation of grasses and heavy forest, usually occurring in clearly defined areas thus giving the country, in places, a somewhat park-like appearance. The principal grass is *Themeda quadrivalvia* with thickets of *Saccharum spontaneum* and sub-species on the banks of streams, while forests contain a large percentage of millable oak (*Quercus* sp.)

The climate is that of perennial spring and, on Aiyura station, it is now a common sight to see strawberries thriving side by side with paw-paws or Papaya (*Papaya carica*) though the latter take longer to reach maturity than at low levels.

Work was started at this station over four years ago for the cultivation of cinchona (quinine) and other mountain crops and the improvement of native agriculture.

The Officer-in-Charge, Mr. R. F. Brechin, has been very successful in all these enterprises, and his influence extends far beyond the tribes in his immediate neighbourhood.

On account of the absence of bamboo and palms at that elevation in the mountains of New Guinea, light native building material is scarce. He has nevertheless constructed a dwelling for himself and wife with walls and roof of grass thatch, and a floor of plaited reeds.

His outside work shows equal enterprise and thoroughness, as the station is well laid out with many economic plants. Sustenance crops of value to natives are receiving every attention and the number of natives from distant villages who come for instruction and planting material is a sure indication that the work done on their behalf is appreciated. The natives have been taught to grow several European food plants, all of which have entered into their own dietary. Potatoes, maize, cabbages, celery, cauliflowers, onions, soy beans, groundnuts, beans, and cucurbits of many kinds are all found thriving on the stations, and many have become established in native gardens. The natives, however, are very thriftless and will devour their whole crops of maize, groundnuts &c., and come to the station for fresh seed for planting instead of saving their own. Cinchona, Arabian coffee of the famous Blue Mountain (Jamaica) type, and many varieties of fruit and other economic trees are also thriving on the station, some of which should be of value in native agriculture.

Goats and sheep (Romney Marsh) have been introduced to the station and are thriving there. The station is now entirely self-supporting as far as rations are concerned. An important activity on the station is pit-sawing of jungle timber, raw bush natives having been trained for such work. Store and other out-houses have now been built from hardwoods (oaks), pit sawn on the station, even the roofs being made of experimental shingles split on the place. All the labour is performed by bush natives trained by the Inspector himself. For the past three years he has been pit-sawing and seasoning hardwoods for his bungalow, and he has now 10,000 superficial feet of various dimensions suitable for the purpose.

The natives are taught not only the cultivation of new sustenance and other economic crops, but how, given the necessary tools, they may go into the jungle, fall and pit-saw timber and work the material into stable wooden dwellings. On the authority of missionaries, miners, and other unprejudiced persons, it can be said that the influence of this Government Agricultural Station has extended well into uncontrolled areas.

The Inspector and Instructor in the Rabaul district was granted war leave, but the Assistant, Botanic Gardens, spends two or three days per week in inspecting and instructing native agriculture in the Taliligap-Kokopo area. This work has added considerably to the duties of the relieving officer, but on the whole, agriculture has been creditably maintained under his supervision. There are 168 native groves and hundreds of gardens for the cultivation of vegetables and sustenance crops in the Gazelle Peninsula, and it cannot be expected that he could regularly inspect them all.

Every possible effort is being made to encourage the production of more sustenance crops, and planting material has been supplied to many natives gratis. The cultivation of ground nuts and maize is extending to many districts and it is a common sight to see the first-named for sale in the native markets. In fact, it has become a regular article of diet in many villages. The cultivation of ground nuts, maize, and European vegetables such as tomatoes, spring onions, carrots, and cabbage is an established industry in the main European centres and is even extending to less developed districts.

Many natives have acquired the taste for European vegetables, which have now entered into their own dietary. Although natives are very conservative, some have even acquired the taste for vegetables common in the southern States of America, India, and other tropical or sub-tropical countries, but which are not appreciated by Australian residents in this Territory. As New Guinea natives are largely root eaters, such additions to their diet should have a salutary effect on their health.

The natives in the Rabaul district are amongst the most sophisticated in the Territory, and in order to train them to be independent, it is no longer deemed advisable to make gratuitous issues of vegetable seeds, except under special circumstances. Natives who have reached such a stage of civilization that they can afford to purchase bicycles, have shares in motor lorries, and copra driers, should be taught to realize their responsibilities and purchase their own seeds, otherwise they or their descendants will never be fit to become native citizens of their own country. New varieties of crops are issued to them gratuitously, and one native has had an orchard of fifteen imported fruit trees lined out and planted for him by the Department of Agriculture. The plants are as follow:—

4	Bambutan	imported plants from Java.
4	Kapeolasan	
4	Langsat	
10	Mangosteen	
12	Avocada Pear	—imported plants from Manila.
2	Grape Fruit	plants grown and seed imported from Manila.
9	Pomelo	
5	Mandarin	
12	Pomelo	plants from seed imported from Hong Kong.
12	Orange	
6	Mandarin	
8	*Garcinia oblongifolia*	
4	Litchee	
12	Orange	—grown from seed from New Ireland.
5	Brazilian Nut	—from Mr. G. H. Murray.

These trees are of considerable value and were introduced by the Department from abroad for the purpose of planting on an area of waste land at Taliligap, several hundred feet above sea level. Being unable to obtain a small area of this land, and as they could not be kept longer in the nursery at Rabaul, an arrangement was made with a "Luluai" to plant the trees on his land. The conditions are that the fruit of the trees are his property, and the Department is free to take all the planting material, seed or vegetable, that it may require for distribution amongst natives or others. An Inspector and Instructor visits the orchard weekly in the course of other duties to see that the "Luluai" maintains the area in good order. Since transfer of the plants from the low elevation of Rabaul, they have made considerable growth.

It is again necessary to point out the evil of shifting cultivation which is going on year by year. To prepare a piece of land for a garden, the native partially falls the timber, which is then burned and, in most cases, the fires spread far beyond the area required for planting. In this way, standing timber and seedlings are destroyed. The process being repeated year by year, noxious grasses take the place of valuable forests. Later, these grass areas are periodically fired to hunt a few pigs and rats, and continue the sad story of land destruction. This shifting cultivation has of course been the custom of primitive races for ages, during which history tells us that much of the earth's surface has been rendered useless. It is within the memory of officers of this Department that a great part of what is now only poor second-growth bush, and even kunai, was once high forest timber. The rapid degradation in the vegetation of the country is a serious matter and must be resisted within a decade, or the future utility of much of the Territory will be imperilled.

Other Governments controlling primitive native races have taken necessary steps to check the evil by the introduction of a system of permanent farming. The Inspector and Instructor at Aiyura, in the mountain district of inland New Guinea, has given this matter careful consideration, and estimates that, even with the native system of so-called rotation under control, 1,000 acres would permit a 40-year rotation for 250 natives.

No time should be lost in defining native lands for cultivation of present and future sustenance crops and legislation enacted to prevent the destruction of the greatest of the Territory's assets, viz., its cultivable land.

Entomologist.

The Entomologist continued as Acting Director until the Director's return on 13th August, 1939, and then proceeded on leave, resuming duty on 10th February, 1940. During the Director's absence on recreation leave, the Entomologist was appointed Acting Director from 7th March, 1940, to 21st June, 1940.

The Assistant Entomologist, Mr. B. A. O'Connor, proceeded on recreation and long leave on 7th March, 1940.

The breeding and field-distribution of *Tetrastichodes brontispae* were continued without interruption throughout the year, the *Brontispa* larvae and pupae being collected from an area of young coco-nuts close to Rabaul. Larvae were fed on fresh leaf in jars at the laboratory and pupae sorted out each day for breeding work. The distribution of parasitized pupae covered the Districts of New Britain, New Ireland, Manus and Kieta; mass liberation for closer observation was made in an area of young coco-nuts in the vicinity of Rabaul, and from this area, the parasites have been recovered on several occasions from *Brontispa* pupae collected in the field.

Laboratory breeding and distribution of *Pleurotropis parvulus* was discontinued towards the end of 1939, as the parasite was well established throughout the Rabaul-Kokopo area, and was reported to be so well established at Lindenhafen as to have the pest under control. Whenever a colony has been required for liberation in any other locality, it has not been difficult to collect a satisfactory supply in and around the Rabaul-Kokopo district, although the degree of *Promecotheca* infestation in this area is very slight.

PEST OCCURRENCES.

Sexava infestations have been reported in portion of New Hanover and in Manus. Damage by large *Dynastid* beetles, *Xylotrupes gideon*, L. and *Scapanes grossepunctatus*, Sternb. has been severe in many parts of the Rabaul-Kokopo District, especially in and adjacent to areas where logs and stumps have been left to rot out after clearing.

Spodoptera mauritia, Boisd. (*Noctuidae*) occurred in large numbers on couch grass around Rabaul on two occasions for short periods. Dusting or spraying with derris or arsenate of lead gave a satisfactory control when undertaken at the beginning of the infestation. *Microdus* sp. (*Braconidae*) was bred from the larvae, and apparently exercised a large degree of control.

Plant Bugs, belonging to the family *Plataspidae*, were reported on a number of occasions from various leguminous crops, especially beans.

Four species of "Shot-hole Borers" were bred from sections of stems of cocoa trees from the Talasea District.

A large *Pentatomid* bug (as yet unidentified) was very prevalent on *Hibiscus tiliaceus* around Rabaul, the egg-masses encircling the leaf stems, and the young bugs feeding on the flower-buds. This insect was bred through a life-cycle series in cages at the office.

Dysdercus papuensis, Dist. was also found breeding on *Hibiscus tiliaceus* in the same localities as the previous insect.

Rhyparida spp. (*Eumolpidae*) have been collected feeding on the young flush leaves of cocoa, and, as stated in other reports, may cause damage to the growth of the young tips when the infestation is severe.

Exopthalmida spp. and *Platyachus ruralis*, Fst. (*Curculionidae*), caused considerable damage to garden plants and shrubs in various parts of the Territory.

Telicota bambusae, Moore, has been reported from areas of young coco-nuts in different parts of the Territory; a *Braconid* parasite (not previously noted) was bred by Mr. G. F. Gee from this *Hesperid*, larvae of the host having been collected in the Namatanai District.

Agrotis ypsilon., Hufn. caused damage to vegetable plants in one area.

The egg parasite of *Brontispa froggatti*, *Trichogrammatoidea nana*, Zehnter, was bred by the Assistant Entomologist from *Brontispa* eggs collected during the latter half of 1939. At the request of Levers' Pacific Plantations, Ltd., a number of eggs of *B. froggatti* were collected in an area in which this parasite was known to be prevalent, and the colony was forwarded to the Manager of the Company at Gavutu, British Solomon Islands.

INSECT COLLECTIONS.

The insect collections have been maintained in good order, and have been increased with specimens collected by the Entomologist, Assistant Entomologist and by members of the field staff of the Department of Agriculture.

In the reference collections of species identified by the Imperial Institute of Entomology and other specialists in various groups of insects, there are now represented 15 orders, 184 families, 771 genera, and 1,335 species; a large number of insects are still with the above institute and others for identification have not, as yet, been returned.

During the year, a number of insects was sent for identification to the Imperial Institute of Entomology, London, covering the Orders *Rhyncota, Orthoptera, Lepidoptera, Coleoptera, Diptera, Hymenoptera,* comprising 254 species.

One hundred and seventy-one identified species were received from the above Institute during the year, of which four species were new to science, eight new to the Institute, seven species were not in their collections, and twenty-three species were retained for further study.

Five species of *Coccidae* were sent to the Entomological Division of the British Museum (Natural History), London, and identified specimens were returned.

Termite ("White Ant") specimens were sent to the Entomological Division of the Council for Scientific and Industrial Research, Canberra, and other insect material to the Entomologist, Adelaide Museum. Identified material was received from the Entomological Divisions of both the above Institutions.

Economic Botanist.

During the year under review advisory and investigational visits to plantations in outside areas were continued. Investigations were carried out on the economic possibilities of various crops while plant-breeding, plant introduction and a certain amount of plant disease work was carried out, mainly at Rabaul and at the Keravat Demonstration Plantation.

The following articles were published in the *New Guinea Agricultural Gazette* during the year:—

(1) "Annual Report of the Economic Botanist for the year 1939-1940." Vol 5, No. 2.
(2) "Some Investigations on Coco-nut Diseases associated with Soil Conditions in New Guinea." (This article was published in two instalments in Vol. 5, No. 3, and Vol. 6, No. 1, issues of the *Gazette.*)

In the hands of the printer are notes on a "Somatic Colour Mutation in a Cavendish Banana Plant," and in the course of preparation is an article on the rubber industry.

PROPERTY INSPECTIONS.

Under an arrangement made by the Custodian of Expropriated Property with the Director of Agriculture, further inspections of old declining properties were conducted. Reports were furnished and, as far as possible, recommendations were made as to possible means of rehabilitation.

The Portland Islands coco-nut plantations were visited in company with Messrs. Richards and Herkert, plantation inspectors to the Expropriation Board. It was found that the position on the Portland Islands, which have shown serious decline in production, closely parallels that of the older and more exhausted areas of the Western Islands and the problems involved are closely related only more exaggerated. The areas carrying coco-nut palms on the Portland Islands may be grouped under three categories as related to the soil and water-table conditions present—

(*a*) Good bearing areas which are economical producers;

(*b*) Areas which are still producing coco-nuts but the coco-nut palms are poorly bearing or uneconomical producers;

(*c*) Worthless areas of palms bearing no crops.

The proportion of uneconomic producing and worthless areas to good areas on these islands is very high and is increasing. Coincident with the spread of poorly producing areas the cost of production increases while the real value of the property decreases.

Those planted areas in the third category are abandoned (e.g., all of the Colenusa and Belligilla Islands). It was recommended that every attention should be paid to keeping up the profitable production of the present good bearing areas and to try and bring the palms on the marginal areas (category (*b*)) back into good production. Introduction of erect and creeping cover crops and conservation of all fronds, husks, and vegetable matter were among the recommendations made. Those badly tapered palms situated on shallow sandy soils and near the central lagoons do not warrant expenditure even on maintenance. The problems involved are discussed in a report on the Ninigo Group, Western Islands, where the soils' geology and derivation of typical coral formations are also detailed. The position on these islands may well be a guide to the ultimate fate of numerous other plantations in this Territory situated on soils of coral type.

Other properties inspected under the same arrangement last season were Djaul Island and properties on Lavongai Island (New Hanover), but *interim* reports only were furnished, as separate soil and maintenance problems were involved. Some reports submitted by the Custodian's inspectors on other properties were submitted for comments and recommendations.

It was of general interest to note that two of the plantations visited on Lavongai were situated on old terraced areas. These well preserved terraced areas were probably old rice sawahs and relics of a civilization long extinct on Lavongai Islands. Samples of the edible sub-soil (red clay), which is eaten by the natives in that vicinity, were brought in for future analysis.

In company with the Chemist an extended visit was paid to various plantations on Bougainville Island and Small Buka Island. Hakau Plantation, which is devoted to coffee and cacao, was visited, and a report furnished to the Directors. On this plantation there is at present 130 acres devoted to coffee and 100 acres devoted to cacao, and planting is being continued. Pruning the coffee seems to be one of the most difficult operations so far as New Guinea natives are concerned, as the "boys" rarely recognize that different bushes require different treatment, depending on their habit of growth. It is the time and labour involved in this class of work as well as in weeding and pest control, which is making coffee a difficult culture at low-levels in this Territory regardless of how much effort and supervision is expended. Pruning operations are not nearly so difficult with *Arabica* coffee at high altitude. Everywhere there was evidence of careful cultivation and the bushes were of good appearance. It was only on exposed ridges or where the top soil was relatively shallow that any backward areas were seen. The cacao had flourished and it was recommended that the cultivation of this crop be energetically carried out, as the combination of coffee and cacao culture should make this a successful venture.

Near Kieta, Aropa Plantation, which was an extensive experimental area in German times, was visited. Coco-nuts, cacao, *Hevea* and *Ficus* rubber had been planted, also some areas of *Hevea* and cacao, and *Hevea* and coco-nuts were interplanted. This latter combination was a complete failure. Advice was given on how to exploit the *Hevea* and *Ficus* rubber present and the tapping of this considerable area has now been commenced. Further south of Kieta and in other areas on Bougainville, areas planted with young cacao were visited and advice given regarding cultivation. Several virgin areas of country were visited (some of which had already been felled) and reported on as to suitability for cacao, coco-nut and rubber culture. On one large area on Inus Plantation, which had been planted with kapok, it was recommended that cacao planted as a mixed crop would give a very profitable mixed culture if a certain amount of shade was used.

Several of the larger coco-nut plantations were also visited and special attention was paid to young coco-nut areas where a "maturation wilt" was apparent in the young plants. This condition has been fully described in a *Gazette* article previously mentioned.

The Chabai Mission Station, where Dr. Hennessy has established a school for training native boys in school subjects and the elements of native agriculture, was visited. Dr. Hennessy had planted up large areas with native foods, the selected seed and planting material having been obtained from Keravat but it was possible to recommend some new crops.

On nearly every plantation visited some attempt had been made to plant considerable areas of native food crops as recommended by this Department and the Planters' Association, in case of emergency.

Coco-nut Cross-breeding and Improvement.

The chief aims in the improvement programme being carried out at Keravat Demonstration Plantation are concerned mainly with increased yield of copra per palm and production of earlier maturing palms because any reduction in the period of coming into bearing will greatly reduce the cost of plantation establishment.

Seed coco-nuts have been introduced to Keravat from all parts of New Guinea and from Fiji, Java, Celebes, Malaya, the Philippines and the Solomon Islands for inclusion in this breeding programme. Selection and cross-breeding work between the dwarf and Markham selections has been completed. The resulting crossed nuts were planted out and already are showing very interesting variations which should yield superior planting material. Those selections included in the cross-breeding plots are just approaching the first flowering stage and will soon be ready for the second generation of selection. The Superintendent, Keravat, has kept detailed records on the yield of nuts, green copra, &c., of the best palms of the Markham regional strain and, as pointed out previously, all the inferior palms were cut out.

This season an intensive programme of artificial intercrossing within the best types of Markham coco-nuts was commenced. It might be pointed out that some of these palms yield 150 nuts per year, while the nuts are double the size and weight of the ordinary tall coco-nut. The selected palms have already been distributed to planters in all parts of the Territory of New Guinea as being well worthy of trial.

About twenty combinations between these best yielding palms have been made by artificial cross-breeding. Wooden stages were built near each palm and all of the flowering spathes used in this work were covered by "Window-lite" cages and fastened at the ends with a double thickness of muslin to prevent any out-crossing. This pollination required several weeks constant attention and was carried on over the week-ends, using a trained Malay and a couple of intelligent "boys" under supervision. The Superintendent is recording the setting and carrying on from the stage already reached with this work and finalized results will not be available until next season.

One Markham selection, No. 21B, which yielded 40 large nuts at three years from planting, is being widely used in an attempt to lessen the time of coming into bearing as indicated. It is only by reducing costs and increasing yields that such cultures will pay at reduced market prices. Further crossing has yet to be done between the selected ordinary tall coco-nuts derived from various sources as in New Guinea and the most promising selections of the dwarf and Markham varieties.

RUBBER IMPROVEMENTS.

Rubber cross-breeding between some of the best yielding rubber trees in the Botanic Gardens was successfully commenced last season. So far only two crosses have been completed, namely, between tree No. 631 by tree No. 608, which were the two best yielders in the test tapping results, and between tree No. 645 and tree No. 631. Seedlings from the crossed seeds were raised, set out in baskets and despatched to Keravat, where they have already been planted out. Next flowering season (February, 1941) it is intended, if possible, to extend this cross-breeding programme.

About one acre of selected seedlings for a bud-wood garden have been planted out in the State Plantation (Economic Section). Here it is intended to increase bud-wood from the best trees available. What are lacking are intelligent Malays or Chinese trained in bud-grafting, both for cacao and rubber propagation.

Duplicate nurseries of some of the best available rubber selections are in Rabaul and have already been used to build up supplies of the best selections for planting of Keravat. Particulars of the more extensive rubber plantings at Keravat will be supplied by the Superintendent.

COFFEE CROSS-BREEDS.

The coffee crosses planted out last season are growing very well, but are not yet sufficiently advanced for further selection work. It is certain that the production of high quality *Arabica* coffee at the correct altitudes in New Guinea should be given every encouragement. It was seen at the abandoned coffee area at Rugen Harbour Plantation that *Arabica* coffee, growing at an elevation of 700 feet only, was still in good heart and producing well despite long neglect. This would not be possible in other countries where coffee rust is present;

CINCHONA.

Mr. Brechin sent in some flowers of the *robusta* type from Aiyura for a close examination as to possible technique for cross-breeding. The vegetative growth and flowers are very similar to coffee, both belonging to the order *Rubiaceae*. The same technique is applicable to both plants both for vegetative propagation and cross-breeding, so the intended selection and cross-breeding will present no difficulty.

CACAO IMPROVEMENT.

Most of the work at Keravat has so far been concerned with seed selection (about three generations) and vegetative propagation. Investigations on the pollination and possible cross-breeding with this crop are also intended, and the technique has been worked out. An isolation plot consisting of selections of pure breeding *Criollo cacao* has been established in the Economic Section of the Botanic Gardens. This move is also intended to insure that the pure *Criollo* mother-trees, which were badly damaged by the eruption, will not be lost to our work.

PLANT INTRODUCTION.

This phase of the department's activities is continuous, but now that Government agricultural stations have been established in the various districts both the recording and distribution of the various introductions have become more complex.

Plants suited to highland culture at Aiyura are often introduced solely for that purpose; also many of the plants sent to Keravat and the other stations are not sent to Aiyura and vice versa. Where seed is of valuable type, but is suspected of carrying internal fungus, it is sown in the Economic Section; also where possible, small plots of the introduced seeds are established at Rabaul for checking purposes.

Dr. McTaggart, Chief Plant Introduction Officer of the Council for Scientific and Industrial Research has continued his kind co-operation in forwarding new and promising introductions from Australia to this department. Some of the most promising introductions brought in during the year are as follows:—

Ground nut strains from Department of Agriculture, Mysore State, India.

Velvet beans from the Department of Agriculture, New South Wales—these flourish in Rabaul and the white seeded variety is particularly liked by natives and is a heavy producer.

Rice varieties.—New upland varieties of rice have been introduced from the Rice Experiment Station at Valencia, Spain, and from the Philippine Islands, but their suitability for local conditions is not yet determined.

Other grain crops such as various kinds of millets, designed to raise the protein value of the native diet have been introduced from India and Australia.

STATE PLANTATION (ECONOMIC SECTION).

That portion of the Botanic Gardens known as the "Economic Section", which is devoted mainly to plant introduction and nursery work, is now being fully utilized, as is stressed in various sections of this report. Except for the Fruit Section and portion of the Nursery Area, the whole section was thrown out of cultivation, following the recent eruption and later, when the old planted areas were completely terraced to prevent erosion, the ground had to be completely manured with compost (developed by the Indore process) and by green manuring.

New varieties of Avocado pears from the Philippines were planted out in the arboretum, also rambutans and mangosteens from Java and citrus varieties from Hong Kong, all of which are growing well.

Nurseries containing *Criollo cacao*, rubber selections and various other crops such as Changi No. 3, Derris, the best rotenone-containing variety available from Singapore, are being built up in this section for distribution. Several grain and fodder crops such as maize selections, pearl millet, Italian millet, broom millet from Fiji, Ragi (*Eleusine cocacana*) selections, and peanuts from India, are doing well. Most of these crops are represented on other stations, although Ramie fibre, *Boehmeria nivea*, is not yet distributed.

Some fodder crops and grasses are also being tried out. There are 25 species of *Desmodium* in this country, and some of these are superior fodder types to most introduced kinds of fodder plants. Several local and introduced species of *Desmodium* are under trial and are being analysed by the Chemist for fodder value. There is an excellent plot of Townsville lucerne, *Stylosanthes sundiaca* established in Rabaul, but its protein value does not appear equal to some of the local *Desmodium* spp.

One local plant sent in by Mrs. Clemens, Botanical Collector, Morobe, as *Zornia* spp. appears to be a good leafy type of fodder plant. It appears that this may also be a *Desmodium* spp., and identifications are being made.

There are local species of sorghum in New Guinea which must be worthy of trial as fodder plants. These are *Sorghum laxifolium* collected by Mrs. Clemens, *Sorghum nitida* collected by Mr. Wood, Inspector and Instructor at Maprik Station on the Sepik, and *Sorghum plumosum*. There are wild varieties of rice on the mainland of New Guinea. Botanical specimens were collected last season but unfortunately the seed was non-viable.

DISEASE INVESTIGATIONS.

Owing to time spent in other projects this work was not greatly expanded except where actual identification was desired. It was found that a serious root rot of velvet beans in Rabaul was due to *Rhizoctonia* spp., probably *R. solani*.

A serious damping-off disease in cacao seedlings from Witu Island was found to be due to the same species of fungus, and recommendations were given as to its control. It appears also that this or a closely-related species was responsible for the disease in the tennis court lawns at Rabaul last season. The soil-inhabiting fungus *Rhizoctonia* spp. appears to be a very common cause of root-rotting in New Guinea.

A root disease of mammees was shown to be most likely due to *Sclerotium rolfsii*, but the exact identity of the soil-inhabiting fungus could not be determined. It spread from the *Crotalaria* cover crop to the mammees. *Sclerotium rolfsii* was unmistakably responsible for stem and root disease in cowpeas and peanuts at Keravat last year. Both of these root-rotting fungi are often found associated with nodular eel worm (i.e., *Heterodera radicicola*) attack on the roots.

So far it has not been possible to identify mildew on rubber leaves here caused by *Oidium hereae,* and it is believed this serious disease is not present in New Guinea. A suspected attack on rubber leaves this season was found to be due to *Gleosporium hevea,* which is not such a serious disease and is frequently associated with insect attack.

Diseased leaves of French beans and velvet beans sent in were shown to be affected by *Cercospora* spp., which is a very common leaf-spotting fungus here.

Specimens of luminous fungi from various plants were sent to the Imperial Mycological Institute at their request and they identified one specimen as being most probably *Armillaria mellea,* a common parasitic fungus. *Marasmius* spp., one of the common causes of thread blight, was also identified from old coffee leaves collected at Vunalama Plantation.

HERBARIUM.

During the year under review 500 specimens were added to the Herbarium, 300 of these being collected by the officers of the Forestry Department and the remaining 200 by officers of the Department of Agriculture. Of the latter, 100 specimens were sent in by agricultural officers stationed in the Markham and Sepik Districts.

Agricultural Chemist's Report.

The Agricultural Chemist joined the staff of the Department of Agriculture on 11th September, 1939. There was a small laboratory and a little apparatus awaiting him in Rabaul, but, as these were not quite adequate for the carrying out of the numerous analyses which he would be required to make, the Administration gave approval for the additional building of a fume cupboard, a store-room and a combined balance-room and office. Also, orders were placed overseas for additional apparatus and reagents.

A considerable portion of the Agricultural Chemist's time has been taken up in work of an advisory nature. Advice has been given on the feeding of poultry, goats and cattle, and on the fertilization of soils. Unfortunately, questions relating to soil deficiencies can only be answered in vague terms until such time as apparatus is available to make actual analyses.

The duties of Editor of the *New Guinea Agricultural Gazette* have also been undertaken by the Agricultural Chemist. This entails a lot of extra work, although, so far, only one *Gazette* has been prepared under his editorship. In future, it is proposed to issue four *Gazettes* regularly each year, and these *Gazettes* will include an editorial and advertisements. An article on the preparation of reptile skins for exportation was written for publication in the *Gazette.*

Since his appointment the Agricultural Chemist has visited numerous plantations on New Britain, New Ireland, and Bougainville Island, during which he discussed local problems with the planters and collected numerous soil samples. A special visit was made to Pondo, and a report which included suggestions for the improvement of the low-lying portions of the plantations was prepared.

To assist in the compilation of native food tables for the recent Native Labour Inquiry, nine brands of tinned meat, as sold in the open market, were analysed for water, protein, carbohydrate, ash and fat. The results of the analyses are published in the *New Guinea Agricultural Gazette,* Vol. 6, No. 2. Five varieties of local taro were also analysed.

One hundred and twelve samples of local milk have been analysed for fat, total solids and solids-not-fat. It was found that these samples were generally low in solids-not-fat, which appears to be common for milk produced under tropical conditions. This and the fact that New Guinea cows yield only about 1 quart of milk per day led to an investigation being carried out on the nutritive value of local pastures and fodder crops. Thirty-seven samples of pastures, grasses, sedges and legumes have been analysed for their moisture, carbohydrate, fibre, protein, ash and fat content.

During the course of these analyses *Desmodium tortuosum*, a legume indigenous to New Guinea, was found to have a remarkably high protein content. The plant is now growing in an experimental plot in the Botanic Gardens and analyses are being made at various stages of growth. The plant has possibilities as a fodder and green manure. Four other local legumes are also under observation. A detailed account of the above investigation will be published in a future issue of the *New Guinea Agricultural Gazette* when further data are available.*

During the year under review, several small analyses were undertaken for the Department of Public Health.

A summary of all the analytical work performed is given in the following table:—

Material.	Number of Samples.	Number of Individual Estimations.
Milk	112	336
Pasture	16	96
Other fodders	21	126
Tinned meat	9	45
Native foods	8	40
Copra	9	9
Rope	1	2
Shells	1	1
Total	177	655

Keravat Demonstration Plantation.

During the year under review no more bush was cut down, but an additional 25 acres were cleared and brought under cultivation; thus, at the end of the year, the total area under cultivation with permanent crops was approximately 340 acres.

Drains were made where necessary through the newly-cleared areas, existing bridges and culverts were maintained, and a new bridge 40 feet long was constructed over the Wanuwut Creek at a point about 20 chains above the main road.

The large bridge on the main road and over the Wanuwut Creek was pulled down, and towards the end of the year work was commenced on a new one. The new bridge when completed will have a single, 70-foot span, 20 feet of which will be above the water; round bush timber stringers 75 feet long, supported by round timber piles set on concrete, will form the under structure, and sawn local hardwood will be used for decking.

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* This work has now been completed and the results appeared in the last issue of the *New Guinea Agricultural Gazette*.

Experimentation in respect to coco-nuts, cacao, and native food crops was continued and extended, and experimentation with rubber (*Hevea braziliensis*) commenced by the planting of experimental areas in Block No. 32.

The outbreak of war early in the year curtailed to some extent experimental expansion, especially in new crops, as Mr. Hurrell, who was permanently appointed to the position of Assistant in October, 1939, was granted war service leave from 23rd January, 1940, and his position is being filled by a temporary officer.

VISITORS.

Excluding departmental officers and many local Asiatics, there were 415 official visitors to the plantation during the year.

METEOROLOGY.

The rainfall recorded during the year was 129.80 inches, an increase of 40.50 inches over last year, and the heaviest ever recorded on Keravat. The heaviest monthly records were July (19.73 inches), October (11.44 inches), November (15.77 inches), February (12.85 inches), June (11.62 inches), and the heaviest falls during a 24-hour period occurred on 7th July (4.04 inches), 23rd July (3.02 inches), 8th October (3.01 inches), 18th February (3.50 inches), 26th March (3.35 inches). There were 237 wet days during the year.

NATIVE LABOUR.

The general health of the labour on the estate was excellent during the year, an average of only 2.40 per cent. being sick per day. One death occurred, and another labourer was accidentally drowned during a flood in the Keravat River.

The policy of employing married labourers, who are allowed to be accompanied by their wives, was continued during the year, and at its close there were 33 women on the estate. There were eighteen children born during the year, and one woman died due to complications during child-birth. The number of children on the plantation at the end of June totalled 32, of which 24 had been born on the estate. No marital troubles were experienced, and the women and children enjoyed good health.

The average number of working labourers on the plantation during the year was 153 per month. A total of 48 completed their contracts of service; of this number, twelve were ineligible for re-signing, and from the balance, 22, or 61 per cent., renewed their contracts for another period.

The diet of the labourers was constantly varied, the rice ration being supplemented by taro, yams, mammees, cassava, sweet potatoes, green maize, and cowpeas. Pineapples, paw-paws, bananas and mature coco-nuts were issued from time to time in addition to the normal ration. The preserved meat ration was supplemented with issues of fresh fish.

On the 21st June, 1940, four specially selected Solomon Island natives arrived on the estate to undergo a course of training in agriculture.

PLANTATION ACTIVITIES.

Cacao.—In March, 1939, yield records from the spacing experiment in Block No. 11 were commenced, and continued throughout the year. The lay-out of this experiment is very simple and consists of two parallel areas, one planted at 15 feet by 15 feet on the square system, the other at 15 feet by 7 feet 6 inches on the same system. The first section contains 670 trees, the other section 1,120 trees.

During the year under review, i.e., 30th June, 1939, to 30th June, 1940, the number of pods harvested was as follows:—

Section A (15 feet by 15 feet) 670 trees .. .. .. = 23,833
Section B (15 feet by 7 ft. 6 in.) 1,120 trees .. .. .. = 26,998

The above yields, based on the number of trees in each section, are equivalent to 35.57 pods per tree in section A, and 24.09 pods per tree in section B. The trees in both areas were planted during September, 1935; thus, at the conclusion of the first full year of recording, they were four years nine months old. It will be seen from the records so far obtained that although the number of pods harvested from section B exceeded by 3,165 those harvested from section A, the average number of pods per tree was 11.48 lower. Frequent tests throughout the year showed that an average of ten pods were required to make 1 lb. of dry cacao. In order to elucidate the foregoing information, the following Table, No. 1, has been compiled:—

TABLE No. 1.

Section.	Distance apart.	Number of Trees.	Age at 30th June, 1940.	Twelve months' yield.	Pods per tree average.	Average pods.
						Per lb.
A	15 feet x 15 feet ..	670	4 years 9 months ..	23,833	35.57	10
B	15 feet x 7 ft. 6 in. ..	1,120	4 years 9 months ..	26,998	24.09	10

During the month of August, 1939, the flat section of Block No. 23, spaced at 12 feet on the equilateral triangle system and containing 1100 seedlings, was planted with first filial generation selections, namely T1, 2, K3A.25, SC.2, EC.34, K3A, 11, RC.3, K4.2. At the close of the year these young trees were making exceptionally good progress and the greater majority of them had ramified. In this block *Leucaena glauca* used both as temporary and permanent shade, is giving excellent results.

In September, 1939, twelve months' yield records were completed from selections in Block No. 11:—

Total number of pods produced = 4997
Average number of pods per tree = 60.20
Total weight cacao produced = 515.73 lb.
Average wt. cacao per tree = 6.21 lb.

Spraying and banding tests against the cacao weevil, *Pantorhytes plutus*, were instituted, but owing to unfavorable weather conditions had to be discontinued.

Towards the latter part of the year the young selected areas in Block Nos. 12 and 22, commenced to ripen pods and many of the trees will be sufficiently advanced to have yield records started in the coming year. Block No. 12 was planted in the months of October and November, 1937, and Block No. 22 in December, 1937.

In April, 1939, the contoured area of Block No. 23 was divided into five sections, four of these sections were planted the same month with first filial generation seedlings from the selections RC.1, RC.2, RC.3, SC.2, and in June the fifth section was planted with first filial generation seedlings from the selection T1.1. During the current year all the seedlings have made excellent growth and the greater majority have ramified.

During the year 10.423 lb. of commercial cacao beans were sold in Australia, and 7,218 selected hybrid and *Criollo cacao* pods were supplied for planting. At the close of the year there were approximately 2,300 bearing trees aged 4 years 6 months to 4 years 9 months and 700 trees over 4 years 9 months old. Estimating at the rate of 10 pods per pound of dry cacao the 7,218 pods sold = 721 lb. cacao, this when added to the 10,423 lb. sold = 11,144 lb. (approx. 5 tons), an average of 3.71 lb. per tree, or at a spacing of 15 feet by 15 feet the equivalent of 742 lb. of commercial cacao beans per acre.

Coco-nuts.

In October 1939 yield records over a period of one year were completed with the 44 selected Markham coco-nuts, mentioned in the last annual report. In March, 1939, an investigation of nuts from each individual selection was commenced and the first series concluded in August, 1939, after six months investigation, in which a minimum of 16 per cent. of the nuts dropped each month from each palm was taken.

Seedlings of the Markham Valley King coco-nut, which were planted in the field during 1938-1939, have made great progress. During the year it was necessary to spray the seedlings three times as a control against *Brontispa* spp. and Skipper butterfly.

Macapuno Nuts.

The small area under Macapuno nuts was sprayed three times during the year, and an application of fertilizer at the rate of 8 ounces per palm applied. The manurial mixture was 2 parts superphosphate, 1 part sulphate of potash, 1 part sulphate of ammonia. The fertilizer has had a most beneficial effect on the nuts, and at the close of the year they were doing very well.

Beetle Pests.

During the year beetle pests were prevalent and large numbers of *Rhyncophorus* spp. larvae and adults, also *Dynastid* spp. adults, were collected. Traps consisting of short lengths of split coco-nut stem, cut surfaces facing one another have given a fairly large measure of control for palm weevils, *Rhyncophorus* spp.

Coffee.

The quantity of hulled coffee sold during the year amounted to 2,042 lb.; there were still stocks on hand at the end of June. The young selections in Block 19 which were planted in 1938-39 have made exceptionally good progress. This area was primarily planted in the form of a cultural and spacing trial, but lack of staff and pressure of other duties prevented the inauguration of the cultural experiments in the present year. However, during the coming year, it is hoped that this work will be commenced, before the trees become too old.

Excellent results were obtained from the re-juvenation experiments in the old *Robusta* coffee block, and during the year many of the stumped trees had flowered and set fruit. The yield of coffee on the estate was relatively lower this year, the main flowering and setting which occurs during May, June, July, and August being greatly affected on account of unfavorable weather conditions.

All coffee on the estate was continually pruned and de-suckered throughout the year, and the shade balance maintained. Re-juvenation by stumping of the balance of the old *Robusta* area is to be carried out during the coming year.

RUBBER (HEVEA BRAZILIENSIS).

During the year Block No. 32 was experimentally planted with *Hevea* rubber, the layout being as follows:—The block was divided into four sections A, B, C, D. Section A was again divided into three sub-sections a, b, c. In sub-sections a and b, double rows of each of eight selections were planted at random, in sub-section c, single rows of each of the eight selections planted in the other two sub-sections, plus three other selections, were planted.

Section B contains double rows, replicated twice, of each of nine selections planted at random, and spaced 10 feet by 10 feet on the square system, and double rows replicated twice of the same nine selections planted also at random but spaced at 12 ft. 6 ins. by 12 ft. 6 ins. on the square system.

Section C is divided into two sub-sections, one sub-section contains seedlings from Koitaki Estate in Papua, the other, which at the close of the year was unplanted, will contain seedlings from Magaria Estate on the mainland of New Guinea.

Section D contains two Rabaul selections which were planted at stake.

At the close of the year the seedlings in Block No. 32 were growing very well, growth being particularly good after the application of a complete fertilizer in April. A section of the block was planted with *Tephrosia candida*, and throughout the whole block a cover of *Desmodium scorpiuris* is being established.

At the end of the year, Block No. 31 was being lined at 20 feet on the equilateral triangle system. When lining is complete the area will be planted with Kaotaki and Magaria selections.

During the year the Economic Botanist succeeded in crossing a number of selections in the Rabaul Botanic Gardens, and in June the following seedling crossings were planted out at Keravat in Block No. 37:—No. 645 x 651, 665 x 631, 631, x 608, 45 x 631, 148, 225, 231, 243, 155, 156, 18, 71. The area planted in this block is lined at 20 feet on the square system.

OIL PALM.

The oil palm areas were maintained throughout the year and a minor pruning carried out. The young areas in Blocks Nos. 4, 5, continued to make good progress. A small number of palms introduced from Malaya in 1934, and planted in the field in 1935, set fruit during the year.

FRUIT AND NUTS.

General maintenance of the fruit and nut sections of the estate was carried out during the year. Rambutans and avocado pears again bore crops. The quality of the fruit produced from the slip-stone variety of rambutan has improved considerably, due probably to the trees becoming older. The crops obtained from both the rambutan and avocado pear were far below those of last year.

Fruit was also produced on the variety of *Achras zapota* introduced from Java; again the crop was very small, but a few seedlings were raised from seed.

The Hawaiian and Queensland varieties of paw-paw continued to yield good crops during the year, and a further area of both varieties was established. Pineapples and bananas bore very well, but as usually happens with the bananas, the fruit is of very little use due to the effects of insect pests. Damage to banana fruit is caused by the banana fruit moth, *Notarcha octasems*; control measures against this moth are the dusting in of pyrethrum powder under the bracts as soon as they lift.

The Queensland nut (*Macedamia ternifolia*) section did not flower again this year. This area contains trees that were planted in April, 1934. They have grown very well but have shown no sign of flowering.

As was reported last year, the citrus area of the plantation is suffering badly on account of unsuitable ecological conditions. The heavy rainfall during the year under review made conditions worse with a result that many of the trees died and had to be cut out. Manuring and pollarding was again carried out but with no success.

ANNUAL ROOT CROPS.

Root crops received a great deal of attention during the year, the principle crops in cultivation being taro, yam, mammee, cassava and sweet potato.

Throughout the whole year a continuous supply of native food was despatched to the Government stores in Rabaul. The total amount of native food sent to Rabaul and used to supplement the rice ration on the plantations was 262 tons made up in the proportion of 169 tons to Rabaul, and 93 tons used on the estate. During the latter half of the year, that is from January to June, the average monthly supply to Government stores increased from 11½ tons to 16.66 tons.

TARO.

Single-plant selection work in connexion with native taro (*Colocasia* spp.) was continued during the year. The 22 new varieties obtained from labour gardens in February, 1939, proved to be inferior to the five named Keravat varieties. Investigations carried out during the year showed that the two Keravat varieties, "Utility" and "King", are much better than the other three varieties "Standard", "Pride", and "Mammoth". These three varieties are heavy yielders and produce exceptionally large tubers. The quality of the tubers, however, is not nearly so good as that of "Utility" and "King", as they are soft and inclined to be "mushy" when cooked. This softness makes the tuber more susceptible to beetle attack whilst the plant is growing. Both "Utility" and "King" are heavy yielders, the tubers are hard and do not become "mushy" when cooked, and there is a definite resistance to beetle attack.

During the year two distinct tuber types were isolated in the "Utility" variety, and although leaf and stem markings are identical, one type produces a round tuber, the other an oval tuber. At the last planting of the single-plant selections of this variety in March, both types were weighed and planted separately. The yield per acre throughout the year of "Utility" and "King" bulk selections, averaged 7 tons per acre, whilst individual yields of up to 6 lb. per tuber were recorded from single-plant selections.

In September, 1939, harvesting of the third generation single-plant selections took place. Yields were so satisfactory that it was possible to establish a new minimum weight of 2½ lb. per plant, and in March, 1940, when the fourth generation was harvested this minimum weight of 2½ lb. was retained.

During the year large quantities of taro planting material were distributed through the Department of Agriculture, working in co-operation with the Department of District Services.

YAMS (DIOSCOREA SPP.)

Taitu variety.—During the month of April, the single-plant and bulk selections of the variety known as "Taitu" were harvested. These selections were planted on the 7th June, 1939, and harvested on the 17th April, 1940, thus the period from planting to maturity was 45 weeks.

The minimum weight for the parent single-plant selection was 21 lb., and the maximum 31 lb.; at the present harvest the average yield per plant was 16.203 lb. from 415 parents, which is equivalent to 29.47 tons per acre. The minimum and maximum weights for the bulk selections were 13 and 21 lb. respectively, these selections at this harvest averaged 10.78 lb. per plant from 815 plants, which is equivalent to 19.60 tons per acre.

When the single-plant and bulk selection planting was made, three sizes of "sets" were used, namely, small, medium, large. At harvest, separate records were kept of the weights from each "set" and it was shown that the highest yields were obtained from the large sets, followed by the medium-sized sets, with the small sets easily producing the smallest crop.

During the coming year when the next generation of single plant and bulk selections are planted the "size of sets investigation" will be continued.

It is worthy of note that the first recorded yield from Taitu yams was made in July, 1939, when unstaked, unselected yams yielded 6.45 tons per acre, and staked, unselected yams yielded 8.80 tons per acre.

In February, 1940, a large native-material yam store was erected, and the crop harvested in April was accommodated without difficulty.

WEWAK YAM.

It will be recalled that in the annual report for 1938-1939 mention was made of the introduction from the mainland of New Guinea of two varieties of *Dioscorea* spp., one white and the other red. Since their introduction these two varieties, now referred to as "Wewak White" and "Wewak Red", have been multiplied to the extent that during the harvest in 1940, individual plant weighings were made and standards set, for single-plant and bulk selection work to commence at the next planting early in the coming year.

In the "Red" variety, single-plant selections were made of 25, 26, 27, 28, 29, 31, 34, 40, 44, 46, 48 lb., bulk selection No. 1 of 20, 21, 22 lb., and bulk selection No. 2 of 13-19 lb.; all below 13 lb. were discarded. In the "White" variety, single-plant selections were made of 20, 22, 23, 24, 25 lb. and bulk selection No. 1 of 12-20 lb., all under 12 lb. were discarded. These yams are exceptionally palatable, contain very little fibre, show every indication of being heavy yielders, and should prove an excellent type for use in the improvement of native food crops.

MAMMEES (*Dioscorea esculenta*).

During the current year single-plant experimental work was continued with the local type of *D. esculenta* known as mammee. The mammee closely resembles the Taitu and Wewak yam insofar as the leaves and stems are similar, and the quality of the tuber is good. However, the mammee, unlike the others, must be harvested once mature, and when stored, quickly loses palatability becoming either hard or mushy when cooked.

On 21st April, 1939, the first single-plant mammee selections were planted, and these were harvested on the 29th March, 1940, after a growing period of 49 weeks. At the time of this planting weight groups were made as follows:—15, 16, 17, 18, 24, 26, 31 lb. In the following table, No. 2, the results at harvest are shown:—

TABLE No. 2.

Parent Weight.	Number of Plants.	Total Yield.	Variation in Weight of Progeny.	Average Weight of Progeny.	Average Weight above or below Parent Weight.
lb.		lb.	lb.	lb.	lb.
15	12	371	25–40	30.91	15.91
16	16	465	25–40	29.06	13.06
17	65	1,621	18–37	24.92	7.92
18	60	1,414	19–43	23.56	5.56
24	7	166	20–29	23.71	0.29
26	8	276	20–38	34.50	8.50
31	12	343	21–37	28.58	2.42

It will be seen from the above table that there were seven single parent plant weight groups, and that in five instances the average yield from the progeny was greater than that from the original parent, further that the greatest increase occurred in the two lowest parent groups, namely, 15 and 16 lb., and the greatest decrease in the highest parent group (31 lb.).

On the 24th June, 1940, the first generation single plant selections obtained from the March harvest were planted out. Analysis of the weights obtained at the March harvest showed that 63.3 per cent. of the plants yielded 25 lb. more per plant, therefore a minimum of 25 lb. was set as a standard and weight groups as follows were established:—25, 26, 27, 28, 29, 30, 31, 32, 34, 38, 40, 43 lb.

SWEET POTATOES.

Cultivation of sweet potatoes on the plantation was greatly increased during the year, and exceptionally heavy crops were obtained. The introduced Giant Toad (*Bufo marinus*) continued to give 100 per cent. control of the sweet potato moth (*Hippotion celerio*).

During the year cultural experiments were commenced with the object of increasing the yield, and results obtained to date are very satisfactory.

The general methods of planting sweet potatoes in the Territory consists of making small, low, hills or ridges, and planting one end of a bunch of cuttings of indeterminate number and length in the top of the hill or along the top of the ridge, little or no attempt being made to make the hills or ridges regular or in lines. In the first series of experiments this local method of cultivation was used as a check, and for comparison large hills and ridges at distance of 4 feet from centre to centre were made. Cuttings for planting were taken from a bearing crop, and three cuttings about 18 inches to 24 inches long, bent in the centre like an elbow, were planted six inches deep, with the bent section in the ground. In each hill the cuttings were planted in five places (top and sides) and in the ridges, the cuttings were planted at intervals of two feet on the top of the ridge, and along the sides midway between ground level and the top. The experimental areas were harvested when fully mature at the age of seven months and yields were as follows:—Check plots, the mean yield was 4.5 tons per acre, large hill and ridge plots, the mean was 15 tons. It is interesting to note that two areas outside the experimental plots which had large hills yielded 17.75 and 20 tons per acre. Only one variety of sweet potato was used, namely, " Keravat Purple " because this variety has for a long time past, proved to be the most reliable yielding type on the plantation.

Test yields were also made with three varieties, " Keravat Purple ", " Red Skin ", and " White ", and the results proved that the " White " variety yielded much less than the " Red Skin ", which in turn yielded a great deal less than the " Purple ". In two parallel plots the yield from the " Keravat Purple " was exactly twice that of the " White ".

CASSAVA.

Cassava is a crop which, prior to the outbreak of war, was not extensively cultivated on the estate, however, as a means for providing sufficient material for research work, in the manufacture of power alcohol, cassava flour, and starch, quite a large area was planted during the months of September and October, 1939.

MINOR ROOT CROPS.

Small demonstration areas of minor root crops such as *Canna edulis* and *Maranta arundinacea* were kept in cultivation.

ANNUAL GRAIN CROPS.

The main annual grain crops in cultivation are maize, cowpea, and rice.

Maize.—Selection of the Keravat strain was continued and large quantities of seed distributed for native and European cultivation throughout the Territory. This Keravat selection is by far the best type of maize growing on the estate, and yields good crops even when planted during unsuitable periods of the year.

The Sweet Corn variety, U.S.D.A. 34, remained in cultivation throughout the year. This variety, despite constant selection does not improve to any great extent, and on two occasions during the year the crop was almost a total failure.

Two new maize varieties were introduced, one a Dent maize known as " Early Morn " which came from Australia, and the other a Flint maize, variety unknown, which was received from one of the local mission stations. The first crop of " Early Morn " was very poor, the stalks grew to an average height of 4 feet 6 inches and the cobs were small and badly filled, the second crop is now ripening and does not show much promise.

The first crop of Flint maize grew fairly well but " lodged " badly just prior to tasselling, the second crop was much better and no " lodging " took place. Present indications regarding these two new varieties are that a great deal of improvement is necessary before they reach the standard of " Keravat " Selection.

Cowpea.—Extensive areas of cowpea were planted during the year; in the dryer months good crops were harvested, but on two occasions although the crop made excellent growth no seed was set on account of wet weather. Rats were again troublesome, especially just after planting and just before harvest when the grain was hardening. Cowpea is a valuable native food, and whenever possible the native labour rice ration was supplemented during the year with cowpeas. A total of 396 lb. was distributed for planting in other parts of the Territory in an endeavour to popularize the crop as a native food.

Rice.—Rice was kept in cultivation throughout the year, and field selection to maintain uniformity of maturity was continued. Two crops were grown, and rat damage was severe in both cases; the rats wait until the seed commences to germinate, and then dig it up and eat it. During the year a total of 459 lb. was distributed for outside planting.

MISCELLANEOUS GRAINS AND LEGUMES.

Millet.—A number of millet varieties were introduced during the year but all failed to set seed due to the abnormally wet year.

Velvet Bean.—Five varieties of velvet bean were introduced from Australia. A small crop was harvested from each variety after the first planting, and the seed obtained was planted in multiplication rows towards the close of the year.

Eleusine Coracana.—This grain crop was introduced but proved a complete failure, only a very small percentage of the seed germinated, and the plants died off when about one foot high.

Haricot Bean.—Two varieties of haricot bean were introduced, namely, "Little Navy" and "Haricot". The former grew poorly and produced a few seeds, whilst the latter proved a rampant grower but up to the close of the year, had not produced any seed.

Lima Bean.—A new variety of lima bean was introduced through the Director of Agriculture. It is a rampant grower (climbing type) but has not yet set any seed.

Fibres.—Demonstration areas of the principal fibres, Manila hemp, Amani sisal hemp, Sisal hemp, Sanseviera hemp, Pineapple fibre, Banana hemp, Kapok, Cotton, Red and White Rozella Fibre, were maintained in cultivation throughout the year.

Spices.—Demonstration areas of vanilla, turemic, ginger, pepper, and cinnamon, were maintained. The cultivation of pepper was extended during the year.

Annual Oils.—Groundnuts were cultivated in small areas during the year as any large scale planting is impossible on account of rats. A small area of *Sesamum indicum* was also maintained.

INSECTICIDES, DRUGS AND MEDICINAL PLANTS.

Small demonstration areas of tobacco, *Tephrosia vogelii, Hydnocarpus anthelmintica,* and castor oil were maintained. During the latter half of the year the cultivation of *Derris elliptica* was extended considerably.

COVER CROPS.

The following species of creeping cover crop are in cultivation:—*Pueraria javanica, Pueraria hirsuta, Centrosema pubescens, Centrosema plumerii, Calopogonium mucunoides, Calopogonium* spp. *Mimosa invisa, Dolichos hosea, Desmodium scorpiurus, Desmodium triflorum.* Small blocks of all species of cover crop were maintained for demonstration and comparison purposes.

GREEN MANURE CROPS.

Green manure crops of *Crotalaria anagyroides, Tephrosia candida, Leucaena glauca,* and Cowpea, were kept in cultivation throughout the year and sufficient areas to supply outside seed demands.

SHADE TREES AND WINDBREAKS.

The chief temporary and permanent shade trees and shrub varieties in cultivation are—*Crotalaria anagyroides, Tephrosia candida, Indigofera arrecta, Leucaena glauca, Erythrina lithosperma, Erythrina glauca, Erythrina micropteryx* and *Albizzia sumatrans.*

Other permanent shade and windbreak trees in cultivation are as follows:—*Albizzia falcata, Adenanthera avaonica, Gliricidia siamea, Cassia fistula, Cassia multijuga, Swietenia mahogani, Hydnocarpus wightiana,* and *anthelmintica, Bixa orellana, Sesbania grandiflora.*

Aiyura Agricultural Station.

For this year, the third since the establishment of this Station, steady progress and development can be claimed. With most of the purely constructional work completed, more time was devoted to crop production and, as the year closes, some financial return after three years of outlay, is in sight.

Cultivation on grassland and in the timber area was extended only slightly to 20 hectares, as it was found that with limited labour, and a very mixed variety of crops under tests, that no reclamation of extended new areas was possible.

Station roads and aerodromes have been maintained in good condition. Although aerial transport has been used exclusively to date, this Department pioneered the first road transport by road from Lae, when in November, Mr. Cantor lead a patrol in from the coast. The practicability of this road route was well demonstrated when it is taken in account that the walking time for the trip was 38 hours.

A feature for the year under review was the introduction of Romney Marsh sheep from Queensland to these highlands in April this year. These did not appear to pass through a period of acclimatization, as they immediately settled down on local pastures and have continued to thrive, although due to loss of the ram *en route* from Australia, there are no immediate prospects of lambing.

The scheme for afforestation inaugurated last year in company with the Forestry Officer (Mr. J. B. McAdam), Wau, to gradually reforest non-arable areas, entered its first practical phase, when nurseries were established and approximately 50,000 seedlings raised.

The most promising crop under test undoubtedly is *Coffee Arabica* (Blue Mountain). Local residents and visitors have been greatly impressed with the excellent growth and the economics of this crop; and as soon as land can be alienated for European development, it is certain that good quality coffee will receive much attention.

A small hydro-electric plant was installed on a local stream, from which power is derived to supply lighting to Station Buildings. Electric fence units have been used with success in the control of livestock.

NATIVE LABOUR.

The average number of labour units employed for the year has been 46 per month, comprised of 18 indentured labourers and 28 casuals (local). This average strength is 9 units less than in the preceding year, and in addition, about 6 units of the present year's strength were small "monkeys" used as interpreters and for light duties. Casual labourers were drawn principally from the Bena Bena area, as these natives are unquestionably superior to local Ramus for plantation work, but a few natives from Kambaidam in the Gadsup Area have had long contact with this Station and remain at work.

The station ration has been as varied and generous as in previous years. Apart from the usual native foods, French beans have been grown in large quantities for use by the labourers. Practically every "boy" has his own garden in which he produces particular delicacies.

VISITORS.

Despite war conditions, there has been a steady flow of visitors to this Station, two worthy of especial mention being Mr. Hore-Lacy, of Rabaul, and Mr. F. Shaw-Meyer, Ornithologist, from the British Natural History Museum. All local Administration Officials have paid periodic calls, as have other Ramu residents. Mr. J. B. McAdam, Forestry Officer, Wau, paid visits in connexion with his work.

METEOROLOGY.

Rainfall for the year amounted to 108.79 inches, distributed over 279 wet days. This exceeds last year's total by 18.81 inches, and again established a new record in rainfall. The wettest months again were March (15.74 inches) and January (13.87 inches), with the lowest fall in June (5.94 inches) and August (4.60 inches). The highest daily gauging (2.95 inches) ever recorded at Aiyura fell on October 25th.

The highest maximum shade temperature recorded for the year was 73.0 degrees on the 23rd December (a record) whilst the minimum air temperature was 51.2 degrees, observed on 30th September (also a record low temperature).

PERMANENT CROPS.

Cinchona three-year-old blocks. These trees which include varieties *Robusta*, *Succirubra*, *Ledgeriana* and the hybrid *Ledgeriana* x *Succirubra* displayed remarkable vigour throughout the year; *Robusta* and *Succirubra* trees now average 15 feet in height throughout the blocks, whilst *Ledgeriana*, which is definitely less vigorous than the grafting varieties, is in a healthy condition and averages about 10 feet in height. The hybrid is the only disappointment, for, as can be expected in a cross-bred, there is a very wide variation in type and vigour, in fact, in view of inconsistencies, these trees will be of little value apart from grafting purposes.

Late in the year, some trees of variety *Robusta* began to carry flowers, the perfume from which is unique and beautiful. However, it is now considered that such flowering was premature, as no seed has "set".

In other countries, apart from Java, *Cinchona* culture has been dogged by misfortune, the tree requiring peculiar physical and chemical soil properties of a fastidious nature. Although it is, as yet, too early to state that *Cinchona* appreciates local soil conditions entirely, the results so far encourage further experiment on a larger scale.

The variety *Succirubra*, during its early growth in the field, while the laterals are still close to the ground, can be propagated vegetatively. As the laterals droop over and touch the ground, a ready strike is obtained by covering the laterals for several inches with moist soil. Rudimentary roots soon appear, followed by the root system; when well developed, the lateral can be cut and the seedling planted out.

Successful propagation has also been made by using cuttings from more than one-year-old wood. Further experiment is proposed in this direction.

One-year-old seedlings.—There are over 5,000 seedlings of this age in the nurseries, which will be ready for transplanting to the field next wet season (September). These are of the variety *Ledgeriana* and the seventh cross *Ledgeriana* x *Succirubra*. In this case, the seedlings show uniformity in type, due no doubt to the seventh crossing back to *Ledgeriana*. The block to receive these seedlings has already been prepared.

Ledgeriana seedlings.—In addition to the above, 2 ozs. of *Ledgeriana* seed was planted into a nursery early in May. Good germination resulted in 35 days (which was delayed). It is impossible to accurately give the number of seedlings as these are still very small, but the bed is of 300 square feet and is well-stocked.

No serious pests have been observed and seedlings and trees have been remarkably free from disease. There have been two isolated cases of "Borer" attack into the base of trees.

COFFEE ARABICA, BLUE MOUNTAIN, THREE-YEAR-OLD BLOCK.

Early in the year this block flowered profusely, and as the year closes is carrying a heavy crop of cherries. For the last two months, harvesting of beans has been regular every ten days. The beans are of good size and quality, some have already been forwarded to Rabaul for inspection. It is not yet possible to give any accurate yields, as the trees are only settling down to regular bearing. All trees were topped at 6 feet, using the single-stem system.

Shade has been gradually reduced until it is no longer effective; the ground cover of *Calopogonium mucunoides* has, of course, been maintained. The block has been free from pest and disease attack.

In May, 75 mother trees were selected for seed purposes on trueness of type, lateral development, node spacing, fruiting ability and size of cherries. Since then these trees have given an average of 1 lb. of beans each week, which has been immediately planted into the nursery, in order that a much larger area of coffee can be tested as soon as possible. After heavy culling, it is anticipated that there will be sufficient seedlings available for a further 30 acre block.

COFFEE ARABICA *ex* KENYA.

Four varieties—Harari, Columnasia, Maragogipe and San Ramon, each of approximately 100 seedlings, were planted without shade in an half-acre block during October. At first, the seedlings were severely attacked by leaf-eating insects, but as soon as shade was introduced these attacks were controlled. Hence, it has again been demonstrated that shading, at least in the early stages of establishment, is a necessity. All varieties are of the multiple-stem type developed in Kenya; later results and growth will be interesting.

TEA, *ex* BRITISH NORTH BORNEO.

A small block of 80 seedlings planted 8 feet x 8 feet has made fair growth through the year, although its vigour does not compare with the other permanent crops. Lateral development has been fairly good; the bushes appear to be perfectly healthy, so that it is concluded that the strain is not the best. It is regretted that it has not been possible up to date to procure seed from more reputable stock. The present height of the bushes is 5 feet.

PYRETHRUM.

This crop continues to be full of promise. The area under crop was doubled during the year and next year it will be possible to plant several acres. Several pounds of seed and dried flowers have been collected, samples of the dried flowers having been forwarded to Rabaul for analysis. Picking of flowers is necessary every ten to fourteen days. It has been observed that as the flowers are picked, so the plant is stimuated to produce. Propagation by cuttings is more effective and labour-saving than from seed. The prospects for expansion of this crop, which is reported to have a market value of £140 per ton at present, appear bright.

FRUITS.

The following fruits are now in full bearing:—

Passion Fruit (*Passiflora edulis*).—Very heavy yields of good quality fruit.
Banana Passion Fruit.—Heavy yields.
Strawberries.—Good quality fruit. A small block of 50 square yards produces 4 lb. a week.
Cyphomandra batacea (Tree Tomato).—These have fruited heavily and continuously.
Pineapple and Cape Gooseberries.
Figs.—A few figs of the Blue Province variety were produced, but were quite tasteless.

The only new plantings into the extensive orchard established last year were more tree tomatoes and Hawaiian papaws. The latter are thriving in a warm, protected corner of the plantation. These are 12 feet high and give early promise of bearing fruit.

Castor Oil.

Extensive planting has been abandoned, as the ground can be more wisely used for remunerative crops. A few trees of the four varieties previously tested --Ramu variety, Java, Bombay and Caledonia—are kept in bearing for seed purposes. If cheap transport becomes a reality, this will be a remunerative crop.

Tung Oil (*Aleurites fordii*).

In November, 23 lb. of seed *Aleurites fordii* were received from Queensland. These germinated satisfactorily and there are now 2,000 well-grown seedlings ready for transplanting to the field upon the arrival of the "wet" season. Local seedlings are very much superior to the 16 seedlings introduced from Rabaul in 1938.

Root Crops.

Sweet potatoes have again dominated this section. About 80 per cent. of the cultivated Station has been under this crop at some time during the year, the average yield for all areas being a little over 4 tons per acre. A line of Bena-Bena natives was observed for one week, when it was found that each labourer comfortably accommodated 15 lb. of uncooked sweet potatoes each day. Admittedly, their working ability is in proportion to their appetites for this staple food. Potatoes, yams, and taro have been maintained in cultivation in small quantities. Although potatoes are now in the fourth generation from original Australian stock, there is no sign of deterioration in size and quality, but it has been found that seed potatoes require a resting period of six months from digging to the next planting.

Annual Food Crops.

Maize.—The variety "Golden Nugget" has been kept in cultivation continuously and has given good all round results. One crop which matured in January did so in very wet weather, yet the cobs did not develop fungus or mould. Yields have not been spectacular, but have averaged 500 lb. of corn per acre. It is not possible to use any fertilizer.

Late in the year, another variety, "Early Morn", was introduced from New South Wales. This variety is a quick grower, and may possibly mature in 90 days. It also seems to have the ability to withstand prolonged wet spells without sunshine, as occurred in June.

Rats have again been the most serious pest of this crop. Largely due to the efforts of Mr. F. Shaw-Meyer, more is known of these rodents. The species most active against maize is the Giant Rodent which, when mature, weighs about 10 lb. and is the size of an opossum. Naturally, it has an appetite in keeping with its size, and if not captured or poisoned in time, will completely wreck a corn crop.

Rice.—Results have again been disappointing, due to "non-setting" of grain. However, three more varieties are under test now—Bomba, Benllech and "Kinastita 10"—these are reputed to be upland types, and the results are awaited with interest.

Indian Corn.—This crop has been kept in cultivation, primarily as a poultry food, for which purpose it has much to commend it. Local natives or indentured labourers, however, do not appreciate it as a food. Yields are heavy, and it has been found that a good second crop is obtained by cutting down the stalks after the first harvest, when fresh suckering is encouraged.

Groundnuts, Rhodesian.—Have been kept in cultivation, two crops of 1 acre each being harvested at the rate of 5 cwt. The nuts are of good quality and flavour.

Soybeans, Yellow Mammoth.—No improvement in earlier results has been obtained. This variety produces an excellent flour for bread purposes, but the plant itself is a dwarf type and does not appear entirely suited to local conditions. A request for the supply of seed of other edible varieties from the United States Department of Agriculture has been forwarded to Rabaul.

French Beans.—Excellent results have been obtained with this crop when interplanted with maize. The growing period is only 10 weeks, so that the beans are havested before the maize is advanced. Interplanted with maize in lines three feet apart, yields of 1,150 lb. of green beans per acre have been obtained. The beans when practically mature are greatly appreciated by native labour.

As the year closes, quantities of up to 1 cwt. each week have been forwarded to Lae for European use.

Sugar-cane.—The Station area was increased tc 1 acre, sufficient to meet labour requirements. The crop appears to thrive on exhausted soil at the end of the rotation. Planted in rows three feet apart, it quickly crowds out weeds and requires little cultivation.

TOBACCO.

An experiment with tobacco has been commenced, the idea being to eventually supply Station needs. Seed of a pipe strain was obtained from Mr. Hore-Lacy. This was raised in a nursery, and the crop gives promise of giving an excellent return. One acre is under cultivation.

COVER CROPS.

Calopogonium mucunoides remains the only effective ground cover. This has been propagated on all areas which require resting and as a means of arresting soil erosion. *Pueraria javanica* has been introduced, but it is devoid of vigour and of no value in weed control. *Desmodium acorniurus* and *triflorium* were eventually established here after much difficulty, but they are of little value as cover crops.

Tangier pea has become even more widely established around the station, and as a cover and sheep feed has good possibilities. Haricot beans also have been found effective when it is only necessary to have a good cover for six-eight months.

VEGETABLES.

The high quality of the more common European vegetables has been maintained, and as the year closes, it is likely that a market exists in coastal towns that will make vegetables of some value. A request from Guinea Airways Ltd., Lae, has been received to supply 3 cwt. each week at a rate of 2d. per lb. for all lines. Production can be expended to meet any further coastal requirements, but in order to do so seeds from Yates Ltd., Sydney, will be necessary as it is impossible to collect local seed for most of the year when conditions are too wet.

PESTS.

A comprehensive collection of insects was made during the year and forwarded to the Entomologist, Mr. Froggatt, for classfication. None, however, are of great economic importance. Rodents remain the only serious pest of annual crops and of mature coffee beans, the sweet pulp of which they appear to appreciate.

SHADE AND DECORATIVE TREES.

Eucalypts and *Acacias* are well established at Aiyura and display good size and growth after two years. About 2,000 seedlings of *Eucalyptus rostrata, globulus, alba, citriodora* and *terotornia* were planted on station hill-slopes during the year. This planting has at least proved one fact; that seedlings planted on cultivated land do much better than those planted in holes in grassland in competition with grass roots. The same remark applies to *Acacias baileyana* and *decurrens*, both of which respond quickly on cultivated areas but poorly in grass country, even when the grass is kept cut.

AFFORESTATION.

Approximately 50,000 seedlings of *Arsucaria hoop* and *klinkii* are in the nurseries, the main nursery being established during October and November, 1939. Seed is being collected again towards the close of this year, although the results of this year's seedfall do not appear as good as for the last year.

TIMBER-SAWING.

Timber-sawing of local hardwoods was maintained throughout the year with an average output of about 1,000 super. feet per month. Most of this timber is being used after a short drying period for station buildings, but the better quality timbers are being seasoned properly for later use. The "carpenter-boy" has done some good work, and the pit-sawn timber structure is of his making. Weather-board roofing is an experimental idea, but it is effective and time will be required to prove its durability. It is proposed to convert all native labour quarters to similar structures.

STOCK.

Goats.—These increased to 46 in number during the period under review, and are in good condition.

Sheep.—The six Romney Marsh ewes introduced from Queensland quickly acclimatized and are doing well on local pastures. A ram is required, however, to make this experiment worth while.

Horses.—One foal was born last November and is now well grown. The two mares are used for hacking around the station and for making longer trips.

Bo Agricultural Station, Namatanai.

During the year, clearing of the site for the Agricultural Station was continued until approximately 40 acres of bush were dropped. As clearing continued, the area was divided into blocks, each containing 10 acres, and two such blocks are now completely planted up. One has been subdivided into nine equal sections and is used for the production of native foods in a four-cycle rotation; the other block has 4 acres laid out in orchard and the remainder of the block is planted to various crops.

The soil on the station is of good texture and improves considerably with cultivation and green manuring. It should continue to maintain good plant growth for many years, despite leaching due to the irregular topography of the block. The maintenance of soil fertility by green manuring, &c., should be easily carried out, as the appearance of the soil improves with the growing of each crop. The upper layers of the soil tend to dry out fairly rapidly, but the lower layers of the soil maintain a good supply of soil moisture.

Apart from the orchard, no permanent crops have yet been planted on the station, but some good annual crops have been harvested, especially maize of the Keravat "Long Cob" type and groundnuts, both "Pearl" and "Spanish Red" varieties. Seeds of both these crops have been distributed to the local natives for planting in their gardens. Papaws (variety Hawaiian) have come into bearing and show promise. The orchard trees are well established and for the most part are making good growth. Cowpeas (*Vigna catjang*) have been used in this section as a cover crop with good success.

For the greater part of the year, casual labour was employed on the station while attempts were made to recruit indentured labourers. The casual line has now been replaced by twelve indentured labourers and attempts are still being made to bring the establishment up to the allotted strength of fifteen labourers.

Native foods grown on the station throughout the year include sweet potatoes (*Ipomea batatas*), Mamis (*Dioscorea esculenta*), Native Taro (*Colocasia antiquorum*), Kong Kong Taro (*Xanthosoma saggitafolium*), Tapioca (*Manihot utilissima*), and Maize (*Zea mays*). Besides being used for the labour employed on this station, supply was made to other departments as shown:—

	lb.
Assistant District Officer, Namatanai	5,089
Namatanai-Uluputur road	4,844
Bopire Bridge construction	556
Department of Public Health, Namatanai	460

During the year the following introductions were made:—

Cowpea, var. Poona ex Lae.
Cowpea, var. Russia ex Keravat.
Kong Kong Taro suckers from Keravat.
Rice, upland, from Keravat.
Italian millet, from Department of Agriculture, Brisbane.
Pearl millet, from Department of Agriculture, Brisbane.
Broom corn millet, var. Scarborough Dwarf, from Department of Agriculture, Fiji.
Maize, long and short cob types, from Keravat.
Townsville lucerne, from Department of Agriculture, Brisbane.
Velvet beans, five varieties, from Department of Agriculture, Brisbane.
Haricot beans, from Yates, Sydney.
Maize, var. Early Morn, from Glen Innes, New South Wales.
Bananas, three varieties, from Keravat.
Pineapples, from Keravat.
Broom corn millet, *Panicum miliaceum,* from Hai Pa Gzu, Durbit.
Broom corn millet, three varieties, from Council for Scientific and Industrial Research, Canberra.
Garden orache, *Atriplex hortensis,* from Council for Scientific and Industrial Research, Canberra.
Subterranean clover, from Council for Scientific and Industrial Research, Canberra.
Ragi, *Eleusine coracana,* from Bangalore, India, two varieties.
Rice, two varieties, from Rice Experiment Station, Valencia, Spain.
Rice, var. Kinastila 10, from Department of Agricultura, Philippines.

All these introductions have been planted on the station, and, with few exceptions, have become well established.

Throughout the year, collections of insects in the district have been made and duplicates forwarded to Rabaul for identification. Many species not recorded in the Rabaul collections were forwarded, and it is possible that some of these specimens represent new species.

Meteorological observations were made daily at the station and forwarded monthly to Rabaul. 128.64 inches of rain were recorded for the year, precipitation occurring on 237 days. The highest fall recorded over a 24-hour period was 5.37 inches on 24th February, whilst the highest monthly aggregate was for February, 29.53 inches being recorded for 23 wet days.

Visits were made to various parts of the district during the year to investigate outbreaks of pests, for the routine inspections of native groves and plantations, and to advise on agricultural matters generally. An outbreak of *Sexava* reported from one plantation in the south of the island was investigated and measures instituted for the control of the pest. On the return trip to Namatanai, all native groves were inspected and, where necessary, instructions issued for their cleaning. All plantations in this section were visited and any necessary advice given. A patrol was conducted on the west coast, as far as Kalili Estate, for the routine inspection of plantations and native groves, and to investigate the incidence of *Sexava* in this section. New plantings are being made on this coast at Lamasbei, Konogogo and Komale Bay and have opened up the district considerably. In addition to coco-nuts, cacao is being planted at Lamasbei and Konogogo with satisfactory results and the young areas are coming on well. Slight traces of *Sexava* feeding are noticeable almost throughout this section, but, except in a portion of Kokola Plantation, the numbers of the pest are negligible.

An outbreak of *Sexava* in an area of young palms at Kolonoboi village necessitated a patrol in that section as far as Karu Plantation, and all native groves were cleaned up during the patrol. A strict watch was maintained on this area and several visits were made to ensure that the measures advised for the control of the pest were being undertaken. The outbreak now appears to have been successfully brought under control. A reported outbreak of *Sexava* at Karu village necessitated visits to that section to investigate the report and to advise the natives on control measures to be undertaken. A further visit was made to see that these instructions were being carried out.

During a routine patrol on the west coast, the presence of *Promecotheca antiqua* was recorded on one plantation and Rapuntaman village. In both cases the infestation was very light, being only in a few localized palms. This is the first time that this pest has been recorded on New Ireland. Accompanied by the Entomologist, a visit was made to all suspected areas and *Pleurotropis parvulus* was liberated in an attempt to control the pest. A further visit to the plantation showed the parasite to be apparently well established and holding the pest in check.

Two visits were paid to the native groves on the east coast, one as far as Sohun and the other to Matankuk, and instructions were issued for the cleaning of all native groves in this section. On the whole the native groves here are fairly well maintained. Much improvement could be effected in the groves, however, by the greater use of cover crops. In some parts there are good stands of *Centrosema pubescens* and *Calopogonium mucunoides* and these growths should be encouraged and the seed used for sowing areas with no cover crops. Cowpea seed has also been distributed to the natives for planting in their groves as a cover crop, and also for planting as a green manure in their gardens.

With the present low price of copra the native is very reluctant to cut or sell the produce of his groves, although in most parts there are ample facilities for trading. There are exceptions in some parts where the natives have erected smoke driers and dispose of the copra to local traders, and in some parts the whole nuts are sold. The natives have been instructed that the nuts must not be allowed to remain in the groves till they germinate, but must be collected regularly and if not used for copra must be fed to pigs, used for food for themselves, or burnt.

Seeds of maize, groundnuts, rice, cowpeas and tubers of Jerusalem artichokes have been distributed over a wide area to the natives for planting, but results on the whole have not been completely satisfactory, especially in the case of groundnuts, where in some instances the natives preferred to eat them. Attempts are being made to establish demonstration plots in each village and to keep them under observation and also to endeavour to impress upon the natives the benefits of crop rotation over the native method of shifting agriculture, which is a very wasteful practice. New crops may be introduced into these plots and the natives' reluctance to plant something new may be gradually overcome.

Some form of transport, such as a utility truck, is badly needed to enable a comprehensive system of native agriculture to be carried out. To enable a scheme for improvement in the native methods of agriculture to be carried out it is necessary to make regular visits at short intervals to the demonstration plots, where instruction can be given during the growing periods of the crops under cultivation and any necessary advice given.

Plantations throughout the district are bearing well and in most cases the average yield has been more than maintained. As an example one plantation increased in yield from 17 tons per month in October, 1939, to 35 tons per month in March, 1940. Those plantations previously affected by the serious *Sexava* outbreak in 1937, and which had been yielding below the average since the infestation, now appear to have completely recovered and are bearing very well.

Young plantations in the district are doing very well. Three such places, Samo, Magah, and Belik plantations are now coming into full bearing and show great promise and the effects of the seed selection in the planting of these properties can now be clearly seen.

Cover-cropping is becoming more popular in the district and almost every plantation is now partly covered, at least, with a good leguminous cover crop. *Centrosema pubescens* is the most popular and appears well suited to the district. *Calopogonium mucunoides* and *Pueraria javanica* are also used, the latter appears well suited to the district and makes extremely vigorous growth wherever grown. For this reason it is not so popular as it is very difficult to locate fallen nuts in the very dense cover. This crop also seeds well in the dry season in Namatanai.

Mealy bug was reported as attacking young Cacao seedlings on two new plantations on the west coast, but oil sprays, applied promptly, had the desired result and quickly brought the infestation under control.

On Bo Station parasites of several pests were recorded. From *Telicota bambusae* larvae two parasites were recorded and each appears to be of economic importance. One was a Braconid wasp, possibly *Disophrys* sp. and the other was a Chalcid wasp not in the Rabaul collections. This latter parasite was also bred as a parasite of the Corn Stalk Borer in maize on this station.

Weed pests in the district include *Sida rhombifolia*, which is being successfully controlled on most plantations by a good cover of *Centrosema pubescens*. In native areas the owners have been advised to hand pull and burn this weed, in preference to cutting it, which seems to cause it to grow thicker and stronger.

Stachytarpheta indica (Blue Rat's Tail) was plentiful in parts but a campaign of eradication of this pest by hand pulling and burning seems to have been successful.

Throughout the district small patches of Milky Cotton Weed (*Asclepsia currasavica*) are to be found and in each case the owners have been advised to eradicate the weed, since there is the possibility of stock being poisoned if it is allowed to remain.

TUNG OIL.

The tung oil tree, *Aleurites fordii*, which is found growing in many parts of New Guinea, is indigenous to China, where it grows wild in the hills near the Yangtze River. The seed contains an excellent oil which has become well known as an essential component in the manufacture of quick-drying paints and varnishes, water-proofing and fire-proofing materials, oil cloth, linoleum, insulating compounds and many other products.

The Chinese way of treating the crop is as follows:—

The fruit is collected in a green state, made up into heaps and covered with straw or grass. Fermentation takes place and the fleshy parts of the fruit rot away until the nuts are easily removed. They are then placed in a large circular stone trough and crushed under a heavy stone roller, which, drawn by an ox or other animal, revolves in the trough.

After being roasted for a short time in shallow iron pans, the crushed mass is thrown into wooden vats with open-work bottoms, over cauldrons of boiling water and thoroughly steamed. Meanwhile, iron rings, about 18 inches in diameter, are placed on the floor and covered with layers of straw whereon the steaming meal is arranged to a depth of several inches, the ends of the straw being drawn over to cover the tops of the cakes which, thereby formed, are withdrawn from the rings and placed on end in sloping wooden presses.

When a press is nearly full of cakes, wooden wedges are inserted in the upper end of the slope and, as these are driven home, one after another, with a hammer, a brown fluid exudes from the cakes and drops into a tank underneath.

This fluid is commercial tung oil and amounts to approximately 40 per cent. of the weight of the seed.

Owing to war conditions, the demand for tung oil has increased and at present prices are exceptionally high. R.C.H.

THE COPRA INDUSTRY.

By R. C. Hutchinson,
Department of Agriculture, Rabaul.

PART I.

Although the present copra situation has been the subject of much serious consideration and discussion, no real solution to the problem appears to have yet been evolved. Coupled with any solution, there are many difficulties although none which are insurmountable. In this article a scheme for the improved and more substantial establishment of the copra industry is suggested. The scheme is designed not only to relieve the present situation but to prevent its future recurrence. Only an outline of the scheme is presented in this article but at a later date it is proposed to deal in greater detail with particular aspects, especially plant and production costs.

The basis of the scheme is—

(1) The cheaper supply of coco-nut oil.
(2) The marketing of the oil in three distinct grades—an "edible grade", a "soap grade" and a "fuel grade".

The Cheaper Supply of Coco-nut Oil.

This can be brought about by—

(1) Carrying out the extraction locally.
(2) Employing the most efficient and cheapest possible means of extraction without regard to the nature of the by-products produced.

The local extraction of oil will no doubt meet with much opposition from shipping companies and those manufacturers of soap and margarine who have dealt with our copra in the past. Such opposition, however, will be of less consequence now than in normal times, and can be overcome.

1. The chief advantages of extracting oil locally are enumerated below:

(*a*) *Cheaper Methods of Extraction.*—The plant required for the extraction of coco-nut oil is most expensive and when once installed is generally required to remain in use for many years before any thought is given to its replacement by more modern means of extraction. As this plant becomes worn and out of date, the cost of extraction continually increases in comparison with the cost of extraction for the most up to date plants equipped with all kinds of automatic devices. This is the state of affairs with regard to the plants which treat much of New Guinea's copra.

If copra were milled locally, only the latest plant would be installed and either a slightly higher price could be paid for copra or, which is more important at the present time, a cheaper product could be marketed.

(*b*) *Cheap Labour.*—In New Guinea, native labour may be obtained for about 6s. per week per man. The hours worked per day are long and there is no loss of time due to daily "smokos" or strikes.

The amount of work performed by a native labourer is not equivalent to that performed by a white man and depends largely upon the kind of work required. Consequently the subject can be dealt with more conveniently under " Production Costs " where the number of men required for each portion of the process will be discussed.

For clerical or more important positions in the mill, Chinese or Malays can be employed for £2 to £3 per week.

(*c*) *A Better Quality Product.*—The quality and value of coco-nut oil depends largely upon the condition of the copra at the time of milling, the highest grade oil being obtained from fresh, well-dried copra. Thus, if copra were milled locally, when it is still fresh, a higher grade oil would result than if it were milled some months later, after shipment overseas.

Copra which has not been dried sufficiently becomes mouldy on standing. The moulds tend to decompose or hydrolize the fats in the copra with the result that the oil, after expression contains free fatty acids, becomes rancid quickly and acquires a dark yellow colour and bad odour. Coco-nut oil, containing free fatty acids which increase in amount when the oil is stored, has to be refined before it is suitable for the manufacture of edible products and this entails additional expense. Furthermore, it has been stated (Walker, The Philippines) that an oil which has been rancid and later refined becomes rancid again more readily than oil that has never shown rancidity. Hence, it is seen that a better quality oil will be obtained from copra which tends to be underdried, if it is milled shortly after it is made and not allowed to remain in storage for some weeks or months in a warm, moist atmosphere prior to and during transport overseas. However, the intentional underdrying of copra should not be tolerated.

In order to obtain a high quality oil suitable for use as food, the copra should not be subjected to any preliminary steam heating before extraction. In places outside the tropics, coco-nut oil is normally in a solid or semi-solid state, and when the copra is pressed or expelled without preliminary heating, the yield of oil is small. The meal is then generally steam heated, after which it is again subjected to further treatment, when the bulk of the oil is obtained. The first oil is of much higher quality than the second fraction.

In New Guinea, coco-nut oil is always in the liquid state and if the oil were extracted locally, the total quantity of high quality oil obtainable in the first treatment would be much higher than if the extraction were carried out in a temperate climate where the oil is in a solid or semi-solid state. Furthermore, less steam would be required, less material would need rehandling and there would be a general reduction in the cost of extraction.

When extraction is not carried out by pressure or expulsion, the physical state of the oil is not so important.

(*d*) *Reduction in Shipping Costs.*—Copra contains about 65 per cent. oil, and to bag one ton there are required 14.5 bags weighing approximately 36 lb. Hence, to export one ton of oil as copra the total weight of material to be shipped and the amount of shipping space required is—

$$\left.\begin{array}{ll}\text{Total weight to be shipped} = & 1\tfrac{1}{2}\ \text{tons}\\ \text{Shipping space required} = & 117\ \text{c. feet}\end{array}\right\}\cdots\cdots\cdots\cdots(1)$$

If the oil were extracted in New Guinea, and shipped in 44-gallon oil drums each weighing approximately 50 lb., then to export one ton of oil the total weight of material to be shipped and the amount of shipping space required would be—

Total weight to be shipped = 1⅛ tons }
Shipping space required = 53 c. feet } ....(2)

If the oil were shipped in bulk,* to export one ton of oil, the total weight of material to be shipped and the amount of shipping space required would be—

Total weight to be shipped = 1 ton }
Shipping space required = 39 c. feet } ....(3)

By comparing (2) and (3) with (1), the reduction in weight, capacity and hence shipping costs when oil is shipped in preference to copra is seen to be most marked.

To export one ton of oil as copra, 22 copra sacks at a pre-war value of 15s. are required. To export one ton of oil in 44-gallon drums, 5½ drums at a pre-war value of £5 are required. Thus the cost of containers for exporting oil as copra is less than when the oil is exported in drums, but it must be remembered that the drums can be used over and over again and have a high resale value whereas second-hand copra sacks are of scarcely any value except, perhaps, within the Territory. Copra sacks will always be required for inter-territorial use and for this purpose bags may be used over and over again until they are worn out.

If oil were exported in drums, and oil for edible purposes would probably have to be exported in this manner, many thousands of oil drums would be required. It would be expensive importing empty drums for this purpose and the number of drums which could be imported full (i.e., containing petrol, &c.) is limited. However, it has been stated that there are large iron deposits on the mainland of New Guinea and New Britain. If this is so, a small industry might even be developed for the local production of oil drums.

It may be argued that when copra is exported its value depends not only on its oil content but also on the copra cake it contains. It will be shown later, however, that under present conditions, copra cake has a higher value as a fertilizer within the Territory than as copra cake on an overseas market.

(*e*) *No impoverishment of the Soil.*—In normal times, the amount of copra exported from this Territory annually is approximately 75,000 tons, and of this amount 26,250 tons are used in the manufacture of copra cake. This copra cake would contain approximately—

Nitrogen	500 tons.
Potash	250 tons.
Phosphoric Acid	125 tons.

Now 75,000 tons of copra = dry meat from 380,000,000 nuts;
= annual yield from 9,500,000 palms;
= annual yield from 200,000 acres, approximately.

(According to Dwyer, *Gazette*, Vol. 2, No. 2, there are 198,051 acres under coco-nuts in New Guinea.)

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* The greater proportion of coco-nut oil shipped from the Philippines to the United States, Japan and Europe is sent in bulk. As coco-nut oil solidifies at about 70° F., it is necessary to provide heating pipes in the tanks of the steamers, in the steel storage tanks at the docks and in tank lorries used for distributing the oil, for the purpose of heating the oil before removal.

There is thus an annual drain on plantation soils of approximately—

Nitrogen	5½ lb. per acre
Potash	2¾ ,, ,, ,,
Phosphoric Acid	1½ ,, ,, ,,

due to the amount of copra cake exported (losses due to loss of shell and husk on some plantations are not taken into account). Coco-nut soils in New Guinea are not very rich soils, an average analysis giving—

Nitrogen	.25 per cent.
Potash	.13 ,, ,,
Phosphoric Acid	.15 ,, ,,

and their impoverishment due to the copra cake (coco-nut oil does not impoverish the soil) exported is a matter of vital importance, as proved by the fact that, although little over 40 years old, many plantations in this Territory are already showing a decline in yield. This state of affairs can only be remedied by returning to the soil the nutrients which have been taken from it. It would be expensive to import fertilizers for this purpose, but if the copra were treated within the Territory it would be a simple matter to return to each planter approximately 1 ton of copra cake for every 3 tons of copra treated, and thus arrest further impoverishment of the soil.

Copra cake for use as a fertilizer should contain a minimum amount of oil and such a cake is produced when extraction is carried out by the solvent process.

2. The extraction of coco-nut oil involves two essential phases:—

(1) the disintegration of the copra or fresh meat,
(2) the separation of the oil.

Modern methods of disintegrating copra vary little in principle, but there are five distinct processes for the separation of the oil. In the last two, fresh meat may replace copra when a water-white oil of exceptionally high quality is obtained. The processes are as follows:—

1. *By Primitive Native Methods.*—The commonest of these methods have been described by Copeland in "The Coco-nut".

2. *By Hydraulic Presses.*—Until recently, the common method of extracting oil was by means of large, powerful, hydraulic presses. Generally there is first a cold pressure to produce oil of the best quality suitable for edible purposes, and then a second pressure after the oil has been treated with steam. Sometimes the disintegrated copra is subjected to a preliminary heating before both extractions. Details of this process are given in Volume 5, Number 1, Page 32 of this *Gazette*.

3. *By Expellers.*—A more recent method of oil extraction is by means of expellers. Working with presses, there is an interruption as often as a fresh charge is required, but the action of an expeller is continuous. The expellers have not been made to effect as perfect an expulsion of the oil as a press, and frequently the meal is pressed after it leaves the expeller. Details of this process are also given in the above mentioned issue of the *Gazette*.

4. *By Bacterial Action.*—The compression process of recovering oil from copra tends to be wasteful and inefficient. However good the compression a proportion of the oil-containing cells always remains unbroken. A more efficient method would be to dissolve or decompose the cell walls and thereby liberate the oil. A bacterium, *Bacillus delbrueckii*, which can be obtained from brewer's malt, has been used for this purpose. It has the advantage of being hardy, vigorous, anaerobic and thermophilic. It decomposes carbohydrates, forming lactic acid and an enzyme which hydrolyses proteins into water-soluble amino acids, but it has no action on fats.

The copra is disintegrated, mixed with ground limestone and a little water to form a mush and a culture of the organism is added. The mixture is kept at a temperature of 50° C. in a container from which all air is excluded. Carbon dioxide is evolved and lactic acid, which is immediately converted to calcium lactate, is formed by the action of the organism on the cell walls. The process is complete in about six days when fermentation ceases. The liberated oil is separated from the residue by filtration.

The chief disadvantage to the method appears to be the length of time required for the process, necessitating a very large incubator space. Nevertheless, it is claimed that the plant is cheaper to erect and maintain than those required for the compression processes.

The solid and aqueous residues from the filter presses are generally converted into cattle feed. The former is dried and the latter evaporated to dryness and the two residues combined. The cake contains approximately 5 per cent. fat.

(5) *By Solvents.*—Perhaps the most efficient and cheapest means of extracting oil by means of solvents. There have been many late developments in the process and these will be dealt with in detail at a later date. It will also be shown that the solvent process has certain advantages over the other methods.

At the present time, most coco-nut oil is obtained by means of hydraulic presses or expellers. This is partly because the bacterial process is of recent introduction and partly because the by-product obtained from compression processes is a valuable cattle feed, whereas the by-product from oil obtained by the solvent process may be of doubtful value as a feed. On the other hand, extraction by the solvent process produces a by-product more suitable for use as a fertilizer than the by-product produced by hydraulic presses or expellers. Despite the fact that copra cake has a higher commercial value as a cattle, pig or poultry feed than as a fertilizer, it is considered a sounder proposition, under present circumstances, to return the cake to the individual plantations for fertilization purposes. It may be returned to the soil directly or it may possibly be manufactured into compost or it may even be used satisfactorily as a cattle feed and returned to the soil as dung, but its use for this latter purpose would depend upon the solvent which had been used. The bacterial method of extraction has much to recommend it but, as already pointed out, the copra cake contains 5 per cent. oil which lowers its value as a fertilizer.

Marketing Coco-nut Oil.

The uses to which coco-nut oil may be put are divisable into three groups:—

(1) For the manufacture of edible products.

(2) For the manufacture of soap, pharmaceutical products, candles, glycerine, &c.

(3) For use as a liquid fuel.*

The use to which the oil is to be put would determine the quality to be supplied and the selling price. For instance, edible oil would be of the highest grade ("edible-grade"), oil for the manufacture of soap, glycerine, &c., would be of a slightly lower grade ("soap-grade") whilst oil for use as a fuel would consist of the lowest grade oil ("fuel-grade"). Also the edible-grade would be sold at a higher price than the soap-grade, whilst the price of fuel-grade oil would depend to a large extent upon the cost of production and the current price of crude mineral oil.

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* The value of coco-nut oil as a liquid fuel is not widely recognized although other vegetable oils have been in use for this purpose for many years. Its fuel value was first demonstrated in the Philippines nearly 10 years ago. As a result of tests carried out over long periods in this Territory, coco-nut oil is claimed to be quite as satisfactory as a liquid fuel as imported crude mineral oil. Recent experiments carried out in Fiji confirm this.

For use in an ordinary crude oil engine, the oil should be purified by boiling it with water for about fifteen minutes. Purification is unnecessary for some engines such as the "Drott" and the "Robey" Semi-Diesel Crude Oil Engine in which there are no valves to become clogged up.

If the oil were to be exported as a fuel to colder countries, solidification could be prevented by the addition of a little kerosene or some such substance. Possibly the substance could be so chosen as not only to prevent solidification but also to neutralize any acidity which might be present and to generally enhance the value of the oil as a fuel. The author is already experimenting with such a substance.

In order that the soap-grade oil could not be bought at the cheaper price and used as edible-grade oil, a denaturant, which would prevent its use for this purpose, would have to be added. Similarly, some substance would have to be added to the fuel-grade oil to prevent its use as an edible or soap-grade oil. At present, experiments are being conducted by the author in an endeavour to find the most suitable substance for addition to soap and fuel-grade oils.

When a market exists for edible oils, obviously the bulk of the oil produced should be sold as edible-grade. However, it may not be economical or desirable to refine lower-grade oils for sale as edible-grade. In the first place, the additional price obtainable may not compensate for the extra cost of refining and secondly, it would probably be desirable to keep open a small market at all times for all grades pending the time when one or two of the markets should wholly or partly collapse. It is unlikely that the market for fuel oil will ever collapse but, on the contrary, will increase as the supplies of mineral oils decrease.

The Present Position.

When the bulk of the oil produced is fuel-grade oil (which would be the position at the present time), transport, milling and overhead expenses would have to be reduced to an absolute minimum in order to produce this oil at a price comparable with that of crude mineral oil and in order to pay planters a fair price for their copra or fresh meat. Fresh meat could only be considered when it is possible to deliver it at the mill a day or so after it is cut. On some plantations copra can be produced for £3 per ton, while on others it costs as much as £7 10s. The average price, however, seems to be about £5 per ton, that is, 1 ton of oil, as copra, can be produced for about £7 10s.

The price which could be paid for copra at the mill would depend essentially on the amounts of each of the three grades of oil produced. If the production of edible and soap-grade oil was high then the price which could be paid for copra would rise far above £5 per ton, but, if it were low, which is an extreme case, then the price would also be low. However, as edible-grade oil would be sold for three-four times, and soap-grade for two-three times as much as fuel grade oil, it would not require the sale of large amounts of these grades to raise the price which could be paid for copra. The price of copra would also depend upon its quality. For instance, a ton of third or poor-grade copra would not receive the same price as a ton of first-grade copra, all of which could be used for the production of edible-grade oil if necessary. However, this side of the scheme will be dealt with in greater detail later.

In order for the scheme to be a success, every plantation in the Territory would have to be a unit—the private exportation of copra could not be permitted—and if the scheme could be extended beyond this Territory so much the better. This arrangement might tend to give two or three firms, who own large areas of plantation in this Territory, a controlling influence in the scheme and in order to prevent the private planter from becoming victimized it would be necessary for all concerned, including the Government, to have adequate representation on a controlling board.

REJUVENATION OF A COFFEE PLANTATION IN THE BELGIAN CONGO.*

By R. Dupret.

The rejuvenation of coffee plantations is an important matter at the present time in the Belgian Congo. Two main factors are involved:—

1. (1) The necessity of keeping the existing areas planted with coffee, in view of the restriction placed on plantations of coffee in the Congo.
2. (2) The necessity of directing attention to intensive culture, to reduce the net cost and the labour required in comparison with the quantity of coffee.

In all projects for the Congo one ought to consider labour requirements not only by the hectare but in terms of the yield of coffee. Thus one might say: 1 hectare of coffee requires one and a half men for extensive culture and two for intensive. Too much stress is laid on the number of hectares and not enough on the number of kilograms yielded. The example of the East Indies in this connexion should serve as a guide.

As a lead towards intensive culture we shall describe here two methods of rejuvenation that tend towards this goal—

(1) Periodical rejuvenation,
(2) Perpetual rejuvenation.

Periodical Rejuvenation.—Consists in postponing the rejuvenation of a block of coffee until it shows the first signs of exhaustion. If, after a certain number of years, say ten, it is noticed that certain plantations are not producing enough, holes 2 feet square and 2 feet deep are dug in quincunx pattern between the coffee trees, immediately after the bad harvest. These holes will then be filled one after the other with prunings and weeds. If possible, compost made from pulp, cotton seed, &c., will be added.

The coffee trees, profiting by this aeration and fertilization, will give two or three good harvests. At the beginning of the year following the preparation of the holes they will already be filled with material that will have formed humus. Let us suppose that the holes are dug in 1940, at the beginning of the rainy season. In 1941, the holes will be filled with humus and young coffee trees planted in them. Thereafter, for two years, the old coffee trees are still kept; the young trees are topped and their primaries nipped off if they develop too strongly.

In the third year, i.e., in 1943, after the picking, the old coffee trees are removed and the plantation is entirely composed of new young trees, three years old, selected for big bean, without a stoppage having occurred in production.

Instead of removing the old coffee trees completely one can stump them and thus arrive at the method that we do not recommend so strongly, namely—

Perpetual Rejuvenation.—The old coffee trees, which we will call A, are stumped; the young ones, B, will be three years old and in production. After six years B are stumped; A, stumped three years before, are producing; after nine years, A are stumped, and so on.

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* *Agriculture et Elérage au Congo Belge*, 12, p. 130, 1938. Translation by R. E. Moreau, Amani.

This method can be applied on especially good soils. Also, the two methods can be combined; that is to say, one can stump once and replace once; remove old trees, manure the ground, and replant.

The extensive part of the "periodical rejuvenation" lies in the establishment of nurseries of first quality; the making of the holes is largely paid for by the increased production of the old coffee trees, which are the first to profit by it; the filling of holes takes place automatically, actually facilitating maintenance work.

Thus, at the cost of a nursery, one has a completely rejuvenated and improved plantation, and there will have been no stoppage of production.

CHEMICAL NOTES.

In Volume 6, Number 3, of the *New Guinea Argicultural Gazette,* a recipe was given for making soap, which included 6 lb. of clean dripping. Since the publication of this recipe inquiries have been received asking whether coco-nut oil could be substituted for dripping. Coco-nut oil could be substituted for dripping but the results would not be very satisfactory. If coco-nut oil is to be used, a more satisfactory formula would be the following:—

Coco-nut oil	282 lb.
Caustic Soda (30°Bé.)	282 lb.
Caustic Potash (30°Bé.)	85 lb.
Sodium Silicate	281 lb.
Water	70 lb.

Coco-nut oil is used to a very large extent in the manufacture of soaps, but almost always in quite small proportions, as a soap made entirely or predominantly from coco-nut oil is unsatisfactory for most purposes. The glycerides of coco-nut oil are of a rather unusual nature, and yield a soap which, although it possesses very good detergent properties, dissolves too rapidly in water. The maximum proportion of coco-nut oil usually regarded as permissible for a toilet soap is from 10 to 15 per cent. Laundry soaps, and especially rapidly soluble soap-flakes, may contain up to 25 per cent. of coco-nut oil.

Soaps containing exclusively coco-nut oil are chiefly the so-called "marine" or "salt-water" soaps, and will lather in sea water, since coco-nut oil soaps are not salted out by moderate concentrations of salt.

1 ton coco-nut oil	equals 8,125 fresh nuts (approximately).
1 ton copra	equals 5,000 fresh nuts (approximately).
1 ton coco-nuts	equals 1,400 fresh nuts (approximately).

(From "An Outline of Malayan Agriculture".)

INSECTS ASSOCIATED WITH THE COCO-NUT PALM.

PART II.

By John L. Froggatt, B.Sc. and B. A. O'Connor, B.A., B.Sc.Ag.,
Department of Agriculture, Rabaul.

In this series of articles it is intended to deal with all insects which have been found in direct association with the coco-nut palm in this Territory. Part I. dealt with the coco-nut tree-hopper, *Sexava* spp. In this part, the major pests of the coco-nut are continued with species of *Hispidae* (Coleoptera), the one of greatest importance to this Territory being *Promecotheca papuana*, Csiki.

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PROMECOTHECA PAPUANA, CSIKI.

Damage by this pest is twofold. The grubs, being true leaf miners, feed in between the two layers of the leaf causing large areas of dead tissues and the adult beetles feed on the surface tissue, which leads to the destruction of appreciable areas of leaf tissue when the beetles are numerous. With a heavy infestation, the palm fronds appear brown, as if scorched by fire, especially when viewed from a distance.

Palms of any age may be attacked by this pest, and although the attack in most cases is relatively mild, there are places where the damage caused has been of particular economic importance, causing loss of palms. There are always contributing factors in such cases. For instance, at the end of 1937 there was a heavy infestation over areas which received deposits of volcanic dust from the eruption in Blanche Bay in May, 1937. Torrential rain followed the eruptions, and caused heavy washaways of the pumice soils in the hills. The washed dirt smothered the butts of palms along the foreshores to a depth of several feet and in these places in particular, a large number of palms failed to survive the eruption damage followed by severe *Promecotheca* infestation. The pest was brought under control by parasites in from three to four months, varying with the intensity of the attack; areas outside those affected by the eruption dust and wash had little more than the usual pest population, and on the fringes, where the population was somewhat greater, the indigenous parasites quickly controlled the infestation.

This pest is known in the New Britain, New Ireland and Manus Districts of the Territory, but is more generally marked in the Manus areas than elsewhere. In New Ireland it has never been reported, to date, in plague proportions, parasites apparently affording a high degree of control, as they do in most parts of New Britain.

Native hosts of *P.papuana* are the sago palm, *Metroxylon sagu*, and the nipa palm, *Nipa fruticans*. Although these are not generally attacked as heavily as the coco-nut palm, they undoubtedly act as a focus of reinfestation wherever found adjacent to plantations.

In one case, where the beetle population was extremely large, eggs were laid on the foliage of oil palms, *Elaeis guineensis*, and, although larvae emerged and penetrated the leaf tissue, they only survived for one day.

Life History and Habits.

A considerable amount of research has been done on this pest in the Manus, Rabaul and Gasmata areas, as well as observations made in the field in other areas.

The Eggs.

The eggs are brown with a thick " skin ", and measure about 2.5 to 3mms. in length. They are laid flat on the undersurface of the foliage usually two or three together, although in some localities four and even five have been not uncommon in the one egg mass. The eggs are covered with a dome shaped mass of frass, the whole measuring from three to four mms. in diameter; the eggs always lie parallel to one another. The egg covering is too thick to permit of observations of the developing embryo.

The egg stage has been found to occupy eleven to seventeen days, the average for all localities being sixteen days.

The Larvae.

The larva is light yellowish in colour with the head brown; the anterior portion of the body is the widest, the posterior segments tapering off; the adult larvae measure 12 mm. in length.

On emergence the larvae penetrate the leaf surface, and feed on the tissue between the upper and lower surfaces of the leaf, thus causing these two layers to separate and die, forming a brown " blistered " area on the leaflets where feeding has taken place. Feeding takes place along the veins of the leaves.

Development of the larvae takes place in three stages, or instars, with a resting period between the first and second instars, and second and third instars, and between the mature third instar larva and the formation of the pupa, known as the pre-pupal period.

The age of the foliage in which the larvae feed appears to influence the length of time passed in the three developing stages, as shown in the following table, in which the periods are given in days, and represent the average for a number of observations made in the Manus District; figures for feeding in mature foliage in New Britain are given in column 4.

—	Young Foliage.	Manus—Mature Foliage.	New Britain—Mature Foliage.
First instar	5.0	8	7.5
Rest	2.6	3	2.5
Second instar	2.8	5	9.2
Rest	2.75	3	3.0
Third instar	6.8	10	8.6
Prepupal and pupal periods	15.75	15	15.0

During the " rest " periods, the larvae retreat from the head of the mine to cast the skin (" moult "); during this time the edge of the area where feeding has been taking place shrivels and hardens, and when feeding recommences this is marked on the wall of the mine as a distinct transverse line, providing a ready means of determining at what stage of development the larvae in the mine have reached at any time. Due probably to this hardening of end tissue, larvae that have just transformed into the second instar are often unable to penetrate this tissue and die.

The larval stages occupy an average of 27 days, with a range of seventeen to thirty days.

The Pupa.

The pupa is brown in colour, and may be present anywhere in the wider portions of the mine; it exhibits a degree of free movement if disturbed.

The prepupal and pupal period occupies fourteen to fifteen days.

A complete life cycle, from laying of egg to emergence of adult, occupies 52 to 63 days; average 60 days.

The Adult.

The adult beetle measures about 1 c.m. in length and .3 c.m. in width at the widest part over the folded elytra (wing covers); the posterior third of the elytra and the thorax and head are dark blue-black in colour, the remainder of the wing covers varying from yellow to orange in colour. In the Manus District, a colour variant has been noted in which practically the whole body is brownish yellow. The thorax in some cases shows a lighter brownish black in colour. The basal half of the antennae is brown with the apical half black.

After emerging from the pupae, the adults remain in the mine for a time during which the tissues harden; they then make a semi-circular cut in the upper wall of the mine, and emerge through this onto the surface of the leaf. Feeding commences very soon after emergence, and is done by eroding the surface tissue on the underside parallel to the veins of the leaf. When the beetle population is large, and the feeding heavy, these lines may coalesce and cause the leaf to curl due to the shrinking of the dead tissue.

The life of the adults has been taken in field-breeding cages, and has been from 115 to 160 days. Copulation was first observed 14 to 22 days after emergence (average nineteen days), after which it takes place frequently. The first egg masses were noted six to ten days after the first act of copulation; oviposition continued from then on throughout the life of the females, but was greater in the earlier period of life. On the average, two egg masses were laid every three days during the earlier period of egg laying, and subsequently at a slower rate.

The period of one complete generation, from egg laying to egg laying, has averaged 106 days with a range of 71 to 138 days.

Control.

BIOLOGICAL MEASURES.

In the course of the study of the habits of this pest, particular attention has been paid to indigenous parasites present in the various localities where it occurs; notes are appended on several parasites and one predator that have been bred from the eggs and larvae in the case of the former, and which has been observed attacking the adults in the field in the case of the latter.

Parasites of the Eggs.

The following parasites have been bred from egg masses *Promecotheca papuana* collected on palms in the field.

Fam. *Eulophidae—Closterocerus splendens,* Kow.
Fam. *Eupelmidae—Anastatus* sp.

Closterocerus splendens, Kow. measures 1.7 mm. in length, and is a metallic irridescent colour with two dark bands across each forewing. It was first bred in this Territory in the Manus District in 1932, and was later bred from material collected in various parts of New Britain; an egg parasite of *Promecotheca* was known to be present on New Britain in 1930, but was not bred out prior to the above-mentioned date.

Anastatus sp. is a small black wasp measuring 1.5 mm. in length and was first bred in this Territory from material collected in the Manus District in 1932, and later was recorded from the Gasmata District, and from the Rabaul-Kokopo District, both on New Britain.

On one occasion in Rabaul, a species of *Scelionidae, Telenomus* sp. was bred from eggs of *Promecotheca*, but no other data are available on its relationship with this host; it is an extremely minute wasp.

Parasites of the Larvae.

The following parasites have been bred from the larvae of this beetle:—

Fam. *Eurytomidae*—*Eurytoma promecothecae*, Ferr.
Fam. *Eulophidae* —*Derostenus* sp.

Eurytoma promecotheca, Ferr. is a small black wasp, the female measuring 3.7 mm. long and the male 1.6 mm. long. It is an external parasite of second and third instar larvae of *Promecotheca*, several parasite larvae often being present on the one host.

This species was first bred from *Promecotheca* larvae collected from several centres in the Gasmata sub-district by the Senior Author in 1930, and was later bred from material collected in other localities on New Britain; to date it has not been recorded from other parts of the Territory.

In Rabaul the life cycle of this parasite ranged from twelve to twenty days, with a maximum emergence of sixteen to eighteen days (av. 16.9 days). In Gasmata the Junior Author found the life cycle to average twenty days.

When fed on honey, the adults have lived for as long as 24 days, but when used in the breeding tubes they were only kept for about eight days and then liberated in the field.

Derostenus sp. is a small metallic blue wasp with white legs; the adults measure 1.2 mm. in length.

This parasite has been bred from the larvae of *Promecotheca* second and third instar collected in the Rabaul-Kokopo and Gasmata areas of New Britain, the Namatanai area of New Ireland, and from various parts of the Manus District.

It is an internal parasite of the grubs, with a life cycle avergaing 16.5 days, with a range of fifteen to nineteen days.

Under normal conditions, a combination of the parasites mentioned above maintains a very good measure of control of the pest, and even in such an extreme case as that referred to previously, they ultimately secured control, and no further major infestation has occurred in this area since.

With both native hosts referred to, *Eurytoma promecothecae* and *Derostenus* sp. have been present with the pest larvae.

On one plantation in the Gasmata sub-district, observations carried out over a period of months by the Junior Author showed that an infestation of *Promecotheca,* which had persisted for a considerable period, was prolonged owing to the fact that in the beginning of a generation, the egg parasites were 98 per cent. to 100 per cent. effective for a short time, and this broke the continuity of the generation and prevented the larval parasites from carrying through in sufficient numbers to take their share in the combined measures of control until very late in the generation, thus permitting sufficient adult beetles to mature as to form a succeeding generation. In this case, the introduction of another parasite, *Pleurotropis parvulus,* Ferr. enabled a more satisfactory carry over of the parasites and a natural equilibrium was obtained.

Introduction of Pleurotropis parvulus, Ferr.

In view of the very great success met with in Fiji and the New Hebrides with the introduction of *Pleurotropis parvulus* from Java, attempts were made to introduce this wasp into the Territory of New Guinea. On two occasions, the colony forwarded, once from the New Hebrides and once from Fiji, failed to survive the journey. A further attempt was made from Fiji, and on this occasion it was suggested that the package should be despatched to Sydney in a ship's cooler. Due to the courtesy and co-operation of Messrs. W. R. Carpenter & Co. Ltd., this was done and on the trip from Sydney to Rabaul, they were carried on ice on the airliner; this colony opened up in excellent condition, about 160 adults being alive. The initial breeding up of stocks for liberation was carried out in Rabaul by the Senior Author, and later the Junior Author took stocks to the Gasmata sub-district, where head-quarters were made on Lindenhafen, where this pest had been bad for a considerable time. Through the courtesy of Messrs. Burns Philp & Co. Ltd. and the Manager of the estate, every assistance was given in developing large stocks for liberation on this and other coco-nut areas where the pest was present in that district.

In Rabaul, the life cycle averaged 20.5 days with a range of 17 to 25 days and in the Gasmata centre the range was 19 to 21 days with third instar larvae and 21 to 23 days with second instar larvae.

The best results in the laboratory breeding work with this parasite were obtained by using fully mature third instar larvae or prepupae.

Colonies of *Pleurotropis parvulus* have been distributed to other parts of New Britain, particularly the Talasea area, to the Manus District and to Namatanai District, New Ireland. In most areas where liberations of this parasite have been made, it has been established with comparative ease.

Ants attacking Egg-masses and Larvae in Mines.

The following species of *Formicidae* (ants) have been recorded attacking the egg masses of *P. papuana*:—

Technomyrnes detorquens, Wlk.
Pheidole megacephala, F.

The following species of ants have been recorded in association with *Promecotheca* mines and attacking the larvae:—

Tapinoma melanocephalum, Fab.
Monomorium minutum, Mayr.
Monomorium floricolor, Jerd.
Tetramorium guineense, F.
Pheidole megacephala, F.

P. megacephala is probably the most important of these species.

Resulting from a large series of counts on Lindenhafen, it was found that 13.7 per cent. of the mines were attacked by ants.

Predator on adults.

A *Pentatomid* bug, *Amyotea reciprocus*, Walk var., has been observed, in the Kokopo district of New Britain, to attack and kill adult *Promecotheca* but it is by no means common, and cannot be considered as more than a minor factor in the control of the pest.

MECHANICAL CONTROL MEASURES.

On small palms, hand collection of eggs and adults, and crushing the larvae inside the mines will often enable an infestation to be checked in the beginning.

On the larger palms, flares made by fastening a half coco-nut husk onto the end of a bamboo pole, impregnating it with kerosene or waste oil and setting it alight can be used to flame the undersurface of fronds, thus killing large numbers of adults, and, if done with care, without harm to the foliage.

Spraying and Dusting.

Experimental tests with various dusts against adults of *Promecotheca* showed that arsenate of lead gave the highest percentage of kill, and derris and pyrethrum dusts gave very poor results.

Spraying with arsenate of lead also gave a high percentage of kill, but was relatively slow in action. Nicotine and lime sulphur spray fluids gave a high percentage of kill relatively quickly, but acted entirely as a contact insecticide.

A combined spray of arsenate of lead and "Black leaf 40" (nicotine sulphate) was the most satisfactory, the former remaining toxic on the foliage, while the nicotine content gave a quick kill of beetles present on the foliage at the time of spraying.

It has been a common practice, when *Promecotheca* is noticed in a plantation, to cut off and burn all fronds on which eggs or larvae are seen. Although this will undoubtedly kill all stages of the pest present, it may also destroy numbers of the parasites, and thus retard the rate of increase of these useful insects. In such cases it would be better to cut off any leaflets showing the presence of grubs, and hang them in wire gauze containers so that, any beetles emerging from the mines will be caught, but any parasites present will be able to escape through the meshes of the gauze; later, this material can be burnt if desired.

BRONTISPA FROGATTI, SHARP.

This species is distributed generally throughout the Territory and, with the exception of the Kieta District, it is not generally a serious pest of coco-nuts; in that district, it is more prevalent than elsewhere in the Territory. It attacks palms of all ages, although it is worse in young palms in the nurseries, and for the first year after planting out in the field. Where an area of young palms is neglected and becomes overgrown with vines, &c., palms up to three years or even more have been found to be strongly attacked, but after the area has been cleaned of all vines and undergrowth, the incidence of the pest decreases very markedly.

The Eggs.

The eggs are oval, brown, chitinised bodies, flattened dorsoventrally, and measure approximately 1½ mm. in length; they are laid end to end, two to four together in a slight groove made in the surface of the leaf tissue; they are usually covered with a slight amount of frass.

The egg period is 4 to 5 days.

The Larvae.

The larva when full grown is pale yellow in colour, and measures about 1 c.m. in length; development takes place in four instars, the periods of which average, 9, 6, 7 and 14 days respectively—the range of the full larval period has been from 30 to 40 days.

The larvae feed on the surface tissue of young leaflets in the unexpanded new shoot ("spear") of the palm, giving rise to an area of dead tissue where feeding has taken place.

The Pupae.

The pupa is slightly darker in colour than the larva, and has the cast larval skin attached to the anal end of the body; it is slightly shorter in length than the larva.

Pupation takes place in between the leaflets, and occupies about six days.

The Adults.

The adult beetle measures 7 to 9 mm. in length and 2 mm. across the widest part (just behind the thorax), tapering slightly towards the anal end of the elytra (wing covers).

The elytra are completely black except for a small portion adjoining the thorax, which is yellow; the thorax is yellow with the head and antennae black.

The adults also feed on the surface tissue of the young leaflets in the opening spear, and have a life of 200 to 220 days. It has been noted that the first eggs were deposited 22 to 23 days after emergence.

Control.

MECHANICAL MEASURES.

By pouring a spray fluid of "Black-leaf 40" (nicotine sulphate) down the opening central shoot ("Spear"), the larvae and adults are usually easily killed, but it has been found in some particularly susceptible hosts that arsenate of lead spray has had to be forced in with a spray pump to obtain control of the pest.

BIOLOGICAL MEASURES.

Two species of indigenous parasites have been bred from host material collected in the neighbourhood of Rabaul, namely:—

Trichogrammatidae, Thrichogrammatoidea nana, Zehntner.

This is an extremely minute wasp, measuring approximately .5 mm. in length, which parasitises the eggs. The period from egg-laying to emergence of adult is ten-eleven days.

Eulophidae, Achrysocharis sp.

This is a minute wasp measuring approximately 1 mm. in length which parasitises the larvae; the life cycle (from deposition of egg to emergence of adult) is nineteen days.

Advice has been received that the former sp. had been bred by R. W. Paine from Brontispa eggs in the British Solomon Islands.

Through the courtesy of Messrs. Levers Pacific Plantations Ltd., a colony of pupal parasite, *Tetrastichodes brontispae,* was sent to us from the British Solomon Islands. It has been bred through a large number of generations in the laboratory in Rabaul, and colonies have been liberated on various plantations in the Rabaul-Kokopo district, and others distributed to other districts of the Territory.

This parasite has been recovered from the field in the Rabaul area from a plantation where liberations have been made for several months, but the numbers collected have not been large.

Other Host Plants of B. Froggatti.

Areca catechu is a very common bush host of both *Brontispa froggatti* and *Oxycephala papuana.*

Metroxylon sagu (Sago palm) is another indigenous host of *B. froggatti.*

In the Botanic Gardens, Rabaul, the following palms have been found to be hosts of *B. froggatti*; *Oreodoxia regia* (Royal palm), *Elaeis guineensis* (Oil palm) and *Washingtonia filifera.* The last mentioned palm was found to be particularly susceptible to the attack of this pest.

OTHER SPECIES OF HISPIDAE ATTACKING THE "SPEAR".

There are three other species of *Hispidae* recorded from this Territory attacking the opening "spear" of the coco-nut palm.

Brontispa simmondsi, Mlk. has been collected in the Manus District (Admiralty Islands). This species is slightly longer than *B. froggatti*, and has the thorax and elytra brown, usually with a dark marking down the middle of the elytra pointed towards the thorax, widening in the middle, and tapering towards the anal end; the head and antennae are black.

Brontispa longissima, Gestro, has been collected in the Wewak District of the mainland of New Guinea. This species is practically the same size as the former species, and has the elytra brown with darker colouring over anal half; the thorax and head are brown, with the antennae black.

Oxycephala papuana, Gerst. has also been collected in the Manus District on both coco-nut palms and *Areca catechu*. It is markedly larger than the other spp. referred to, measuring slightly more than 1 c.m. in length and 3 mm. in width.

The elytra are deep black, the head and thorax yellow to orange-brown with the basal portion of the antennae brown, and the apical portion black.

REFERENCES TO PREVIOUS PUBLICATIONS ON COCO-NUT HISPIDAE.

Entomological Bulletin No. 1, 1931, Department of Agriculture, New Guinea.
New Guinea Agricultural Gazette, 2, 1, 10-12
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REVIEW.

In an article by A. G. Van Veen (Geneesk. Tijdschr. Nederland.—Indië, 1938, 78, 2548-2552), it is shown that the food value of young cassava (tapioca) leaves, either steamed or boiled, is uncommonly high. The average composition is—water 77 per cent., soluble carbohydrates 3.3 per cent., fat 1.2 per cent., crude protein 8.2 per cent., crude fibre 7.8 per cent., ferric oxide .01 per cent., lime .28 per cent., and phosphoric acid .3 per cent. The leaves contain less hydrocyanic acid (.02 per cent.) than the roots and cooking completely removes it.

It is shown that the vitamin content of cassava leaves is also high. The sample studied contained 72 per cent. moisture and 8.5 per cent. crude protein: 100 g. raw leaf gave 116 g. steamed and 136 g. boiled. In steaming about 1/7th and in boiling about 1/4th of the dry matter was removed by extraction. Chromatographic analysis showed that almost all the carotene of the leaves was β-carotene: 100 g. fresh leaf gave in the raw state 13,000 I.U. vitamin A; 100 to 110 I.U. vitamin B_1; 145 to 185 mg. vitamin C and 430 γ-lactoflavin: after boiling, 16,000 I.U. vitamin A, about 50 I.U. vitamin B_1, 24 to 36 mg. vitamin C; after steaming, 15,000 I.U. vitamin A, about 100 I.U. vitamin B_1 and 52 to 75 mg. vitamin C. The value of 13,000 I.U. vitamin A is possibly too low on account of difficulty of extraction from the raw leaf.

Analysis showed that about 75 per cent. of the crude protein is true protein and feeding experiments with rats showed that the feeding value is high, although not quite as high as that of the protein of soya beans.

THE UTILIZATION OF HUSKS ON COCO-NUT ESTATES.*

By M. L. M. Salgado, Ph.D., B.Sc.

Ceylon Coco-nut Research Scheme.

Husks form one of the important by-products of the coco-nut palm, the economic utilization of which plays an important part in the successful cultivation of coco-nut estates. When prices are attractive it is the practice to sell husks to the fibre mills, often without an adequate return when the manurial value and the moisture conserving properties of husks are considered. In districts where fibre mills are not available husks are often allowed to accumulate in heaps, the proper disposal of which forms a problem. It is the object of this leaflet to indicate the most profitable ways in which they can be utilized.

1. Properties of Husks.

First must be considered the manurial and other properties of husks on which their agricultural value should be assessed. The main manurial constituent in husks is potash, which forms nearly 30 to 35 per cent. of the ash. On an average, about 100,000 husks contain potash equivalent to 1 ton of muriate of potash, and on this basis alone, husks are worth about Re. 1.50 a thousand. The amount of phosphoric acid is small being only 2 per cent. of the ash.

The potash is present in husks in a form that is soluble and easily available to the roots when they are buried in the soil. Being soluble, potash of husks is leached out when open heaps are exposed to heavy rains.

When husks are buried in the soil, their moisture holding properties are extremely valuable in times of drought, and their spongy structure provides a good medium for root development.

2. Husk Ash.

On some estates husks are burnt to produce ash, which is used as manure. *As a rule the burning of husks cannot be recommended except when it is anticipated that more husks will accumulate than can be buried in trenches or otherwise utilized.*

The following points should be noted in the preparation and utilization of husk ash:—

(*a*) The husks should be from heaps that have not been exposed to heavy rains. Ash from so exposed husks will be of poor quality.

(*b*) The preparation of the ash should be carried out under a slow fire to obtain the maximum recovery of potash; high temperature should be avoided as potash salts are likely to be lost by volatalization.

The pit or heap in which the husks are burnt should be continuously charged with fresh husks in order to maintain a slow smoky fire.

(*c*) High temperatures, especially when the husks are contaminated with sand, tend to produce hard masses of ash in contrast to the fine powder produced under a slow fire. Contamination with sand and stones should be avoided.

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* Ceylon Coco-nut Research Scheme, Leaflet No. 5.

(*d*) Husk ash should be stored in a dry place as it absorbs moisture.

(*e*) Owing to the alkalinity of husk ash, it is not safe to mix it with ammoniacal manures such as sulphate of ammonia or "nicifos", as these would react with loss of ammonia.

(*f*) Husk ash prepared on estates usually contains about 20 to 25 per cent. potash. Two pounds of such ash may be considered equivalent to 1 lb. of muriate of potash.

3. Husk Mulches.

Coco-nut husks are used as a mulch for the conservation of soil moisture in two ways—(*a*) mulch round the base of palms; (*b*) broadcasting husks between palms.

(*a*) *Husk Mulch Round Base of Palms.*—This is the usual method of husk mulching adopted on coco-nut estates. One layer of husks is placed with the convex side facing upwards from about a foot from the base of the palm up to a distance of 6 to 7 feet.

This method of mulching is particularly beneficial on gravelly soils in conserving moisture during periods of drought. Further, husk mulches applied on the manure trenches round palms help to smother the heavy growth of weeds round the base of the palms that follow manuring.

(*b*) *Broadcasting Husks between Palms.*—Broadcasting husks in the fields between palms is as a rule not to be recommended, except when husks cannot be otherwise disposed of, and in any case not on sandy soils. It has given good results on gravelly and lateritic soils which usually suffer most during periods of drought; on such soils it may be considered a cheap way of utilizing husks to advantage when burying in trenches is not possible owing to the expense involved. On other soil types broadcasting husks should be done with caution.

Husks when broadcast seem to decay sooner than when buried though the reason for this is not apparent. After two years the husks are found to be partially decayed.

In order to avoid surface rooting it is essential that after a period of two years the partially decayed husks should be ploughed in.

The use of husks as a mulch either round the palms or by broadcasting should be avoided on sandy cinnamon soils on which this practice has a tendency to produce a surface mat of fine roots.

4. Burying Husk in Trenches.

The ideal method of utilizing husks is by burying in trenches. There is no better method of conserving soil moisture in the soil and reducing to a minimum the serious effects of droughts which most coco-nut estates in the North-Western Province have to anticipate. As one of the causes of immature nut-fall is considered to be deficiency of soil moisture, husk burying would help to reduce its incidence during periods of drought. It should therefore be the endeavour in all coco-nut estates to include a certain amount of husk burying in their cultivation programmes, as it forms a capital investment by improving the condition of the soil. All types of soils benefit by this practice, though as a rule gravelly soils and sandy cinnamon soils show the best results.

There are numerous methods of burying husks in trenches to some of which brief reference will be made, while the method recommended in this leaflet will be described in detail.

(*a*) *Burying Husks in the Centre of Four Palms.*—In this method husks are buried in a small pit 4 feet by 4 feet and 3 feet deep, or circular with a diameter of 6 feet and 1 foot deep (in this case called "saucer pits"). This system suffers from the disadvantage that the husks are concentrated at a great distance from the palms, and further that a husk pit at the centre interferes with the free use of cultivation implements such as ploughs and harrows.

(*b*) *Burying Husks Between the Rows of Palms.*—The second method usually adopted is to bury husks in long trenches between rows of palms ("long line trenches"). The trenches are about 8 to 10 feet broad and run along the whole length of the row. Where such trenches are adopted solely for husk burying a very large amount of husks has to be used and concentrated on one portion of the estate. Interference with the free movement of cultivation implements is a further disadvantage.

In this connexion it should be mentioned that the practice of burying husks in narrow drains, barely 3 feet wide, is hardly to be recommended. Often catch-water drains are filled with husks, thereby defeating the purpose of these drains.

(*c*) *Burying Husks in Trenches Along Rows of Palms.*—This method described below appears to be increasingly adopted in estates where husks are buried and is to be preferred to the two methods already mentioned.

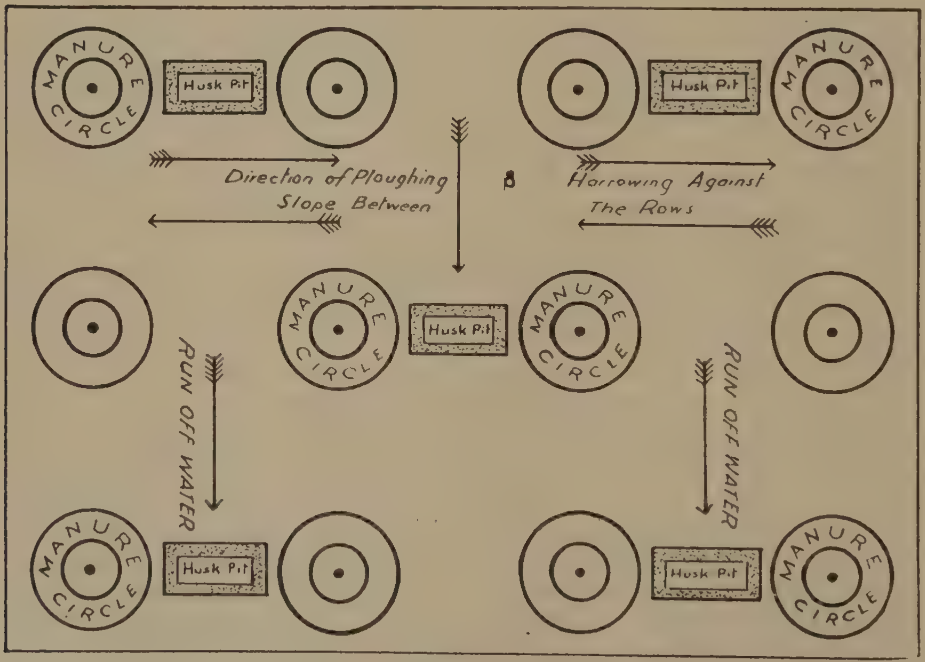


Diagram I.
Arrangements of Husk Pits.

This system of husk trenches is diagrammatically illustrated in Figure 1 and has the following advantages:—

(i) A reasonable amount of husks are used so that, rather than concentrating on one field, the entire estate can benefit from husk burying.

(ii) The husk trenches are not far removed from the palms and thus the roots of the palms on either side can quickly grow into the husk pit and make use of the potash and moisture conserved.

(iii) There is little interference with the freedom of use of ploughs and harrows.

The trenches are alternately arranged along the rows against the slope of the land, the dimensions being 10 feet long, 4 feet broad, and 1½ feet deep. A depth of 1½ feet is considered sufficient, as the advantages of the use of deeper pits are not commensurate with the extra expense involved.

Husks are buried layer by layer, each layer of husks being covered by a layer of earth. It was formerly recommended that the husks should be arranged so that the spongy inner side faces upwards. Examination of husks buried in various ways has shown that there is no particular advantage in systematically arranging husks in this manner so long as each layer is covered by earth. The pit is filled so that the last layer is flush with the level of the ground and the balance of earth is mounded on top.

A pit of this size would take about 250 to 300 husks.

In the cycle of cultivation, when husks have to be buried again in the same field, trenches can be dug in the alternate position.

(*d*) *Addition of calcium cyanamide or lime to husk trenches.*—It is sometimes the practice to add calcium cyanamide or lime to hasten the decay of husks buried in trenches. This appears superfluous. The potash in husks that forms the only manurial constituent of importance exists in soluble form and will be available even without the breakdown of the husks. On the other hand coco-nuts being a perennial crop there will be no advantage in husks decaying too soon. The moisture holding properties of husks which are of particular value to the palms will continue to function without the husks breaking down, and rather than the rapid decomposition caused by cyanamide or lime being of value, it may be considered even disadvantageous.

(*e*) *Planting Green Manures on Husk Trenches.*—Cover crops and erect green manures such as Boga or Crotolaria can be readily established on the top of husk trenches where other methods have failed.

When manuring has to be done in a field where husks have to be buried an excellent practice is to grow Boga about nine to ten months before manuring is due, so that loppings can be obtained for use with artificial manure in manure trenches.

(*f*) *Husk Burying and the Breeding of the Coco-nut Black Beetle.*—There seems to be an idea, particularly in the Southern Province, that the coco-nut black beetle breeds in trenches where husks have been buried. It may be definitely asserted here that where husks *alone* are buried this is not the case. It should also be mentioned that the butt-ends of fronds should never be buried with husks as the former favours the breeding of the black beetle.

5. Husks Vs. Coir Dust.

It is sometimes asked whether it is not a more economic proposition to sell husks to the mills and use the equivalent returned coir dust on the estate. This is based on a lack of understanding of the properties to which husks owe their agricultural values. Coir dust has little manurial value compared to husks, as all the potash has been leached in the process of retting. Further, coir dust should not be buried in trenches as it tends to get caked up and also favours the formation of a dense mat of fibrous roots.

6. Use and Misuse of Husks on Water-logged Land.

It is a common sight to find water-logged land, particularly round Chilaw and Madampe, where the drains are filled with husks. As the object of the drains is to remove excess water and lower the water-table, refilling with husks would only defeat the purpose of draining.

On the other hand husks can be used with advantage on such lands to raise the ground level round the palms and thereby lower the water-table and increase the effective range for root development. This can be done by placing a layer of husks, with the convex sides facing upwards, and covering with silt removed from the drains. In extreme cases of permanent water-logging drains are cut between all the rows leaving a raised platform round the palms. This method is no doubt expensive but produces excellent results.

ENTOMOLOGICAL NOTES.

Inquiries are often made to the Entomologist Division in reference to the control of insect pests with very meagre or no details of the type of damage, or of what the infested crop is, and seldom, if ever, are any specimens of the pest submitted.

Without the guidance of specimens of the pest, and full details of the crop attacked and the degree of infestation, it is often impossible to tender any definite advice.

Hard-bodied insects, such as beetles, bugs, &c., can be forwarded in a small bottle with methylated spirit. Never send specimens loose in an envelope as such are liable to arrive in too crushed a condition to permit of any identification whatsoever.

Caterpillars and other such-like insect bodies should, whenever possible, be forwarded in a small box or well-perforated tin with some of the native food plant; they should never be sent in an air-tight tin, as they will only arrive rotten in such cases.

Insects such as moths, &c., are best folded in paper, and sent packed flat in a closed tin, or other similar container.

PLANTERS ARE INVITED TO SUBMIT SUGGESTIONS
FOR THE IMPROVEMENT OF THE *GAZETTE.*

DESICCATED COCO-NUT RECIPES.

(By The Ceylon Coco-nut Board.)

Coco-nut Cake.—Two cups of desiccated coco-nut (soaked in milk), two eggs, one cup of sugar, half a cup of milk, two cups of flour, two tablespoonsful of butter, one half-teaspoonful of soda, one teaspoonful of cream of tartar.

Another Way.—Two cups of desiccated coco-nut, one and a half cups of sugar, one pint of flour, six eggs (well beaten), one teaspoonful of soda, two teaspoonsful of cream of tartar.

Coco-nut Bread Pudding.—Soak half a cup of desiccated coco-nut in boiling milk for half an hour or more, then add it to the usual bread pudding preparation. This will be found very pleasant and economical.

Coco-nut Puffs.—Mix two cups desiccated coco-nut with one cup of powdered sugar, the beaten whites of two eggs, and two tablespoonsful of flour; drop on buttered tins and bake quickly.

Coco-nut Macaroons.—Take quarter of a pound desiccated coco-nut, half a pound finely-sifted sugar, and the whites of four eggs, beaten to a firm froth. Mix well, and drop little balls of paste upon a well-buttered tin, and bake in a moderate oven for about twenty minutes.

Coco-nut Pie.—One cup of desiccated coco-nut, soaked in milk, three eggs, two tablespoonsful of cornflour, little butter and salt and sugar if wanted; grated rind of lemon improves. Bake without upper crust. It is delicious cooked in almost any manner.

By soaking the desiccated coco-nut in boiling milk it improves in all cases.

Coco-nut Fingers.—Ingredients: 2 oz. of butter, 3 oz. of castor sugar, 6 oz. of desiccated coco-nut, a little cochineal, 2 oz. of flour, two eggs, half a tablespoonful of boiling water. Beat the butter and sugar to a cream, add the eggs one at a time and beat well. Add 4 oz. of desiccated coco-nut to the cream, then add the flour and baking powder. Pour the mixture into a long sponge tin lined with greased paper and bake in a moderate oven for twenty minutes. Leave until cold. Mix the icing sugar with the boiling water and spread on the sponge mixture. Mix the remainder of the desiccated coco-nut with a few drops of cochineal and sprinke on top of the icing. Cut into fingers before icing is cold.

Coco-nut Custard.—Ingredients: One tablespoonful of jam, ½ pint of milk, 4 oz. of desiccated coco-nut, ½ oz. of butter, 1 oz. of sugar, 6 oz. of short crust pastry, two eggs.

Line a greased piedish with the pastry, trim and decorate the edges and spread a layer of any kind of jam at the bottom. Boil the milk with the butter, then pour it over 3 oz. of desiccated coco-nut and sugar and allow to cool. Add the yolks of eggs and stir. Pour the preparation into the dish and cook for 30 minutes in a moderate oven. Whip the whites of the eggs to a stiff froth, pile on the top of the pudding, dredge with sugar and desiccated coco-nut and put in the oven to brown.

Mutton Curry.—½ lb. mutton cut into small pieces, one teaspoonful curry powder, two teaspoonsful salt, four teaspoonsful onions, cut fine, one teaspoonful butter, ½ lb. desiccated coco-nut, fine. Add the curry powder and the salt to the mutton and stir well. Pour ¼ pint boiling water on the desiccated coco-nut and let it soak for five minutes. Then squeeze out milk, preferably with the hand, and pass the milk through a strainer. Fry the onions in the butter (in a saucepan) until they turn a golden brown. Add the mutton and fry for ten minutes over a slow fire, then add the coco-nut milk, cover the saucepan and boil over a slow fire for twenty minutes. Take down as soon as a thick gravy is formed, and add one teaspoonful of fresh lemon juice.

NOTE.—The following curries can be made in the same way:—Prawn, fish, chicken and liver.

Cabbage Mallung.—2½ oz. shredded cabbage, the tender inner leaves in preference, one dessertspoonful desiccated coco-nut, fine, one teaspoonful onions, cut fine, one ripe chilli, cut fine, two teaspoonsful salt. Boil the cabbage with the onions, chilli and salt in eight dessertspoonsful of water until the water evaporates. Add the desiccated coco-nut and stir well over a slow fire for five minutes. When large quantities are cooked the stirring should continue longer, if necessary (until all trace of the water disappears).

PREPARATION OF CHOCOLATE.

The process for treating cacao beans has remained practically the same except for mechanical improvements for many years, although the use of the products has grown and changed. The beans, upon arrival at the factory, are cleaned and sorted before grading. They are then roasted in rotating drums at 260° F. to 280° F. to develop the aroma and flavour. The beans are then cracked into "nibs", the shell pieces being winnowed off. This cacao shell, formerly wasted, became used as a fuel because of its high B.T.U. content and is now finding increasing use in fertilizers and medicines. The "nibs" are ground by mill stones or steel rollers, during which the heat produced melts the cacao butter, about 50 per cent. of the bean, and there emerges a thick chocolate brown fluid. This, when cooled, forms the unsweetened chocolate of commerce. It can be mixed with sugar, nuts, and spices to form ordinary chocolates or with milk, powdered or condensed, &c., to form milk chocolate. The "mass" as the brown fluid is called, is next sent to a hydraulic press, where it is subjected to a pressure of 6,000 lb. per sq. in. to remove a portion of the cacao butter. The cake left in the press is ground up and forms the cocoa powder used for making drinks. The cacao butter is the final product and is widely used in cosmetics, confectionery, and pharmacy.

A REPORT ON THE POSSIBILITY OF PRODUCING POWER ALCOHOL IN NEW GUINEA.

By R. C. Hutchinson,
Department of Agriculture, Rabaul.

Introduction.

Petroleum deposits are irreplaceable and, at the present rate of petrol consumption (300,000,000 tons per annum), will not last indefinitely. Because of this, and the paramount importance of motor fuels in modern civilization, especially at the present time, numerous efforts have been made in recent years to develop substitute motor fuels with which to supplement petrol. Quite a number of chemical compounds and mixtures of these compounds have been successfully employed in the modern type of internal combustion engine but the most successful and widely used of all these compounds is ethyl alcohol which, when used for industrial purposes, is usually termed "industrial" or "power" alcohol.

The value of power alcohol as a substitute fuel has been widely recognized for many years and many national efforts aiming at the establishment of power alcohol industries have been made. In Great Britain during the Great War, an Inter-departmental Committee was formed to report on the production and utilization of power alcohol and related problems. It is interesting to note that the committee came to the conclusion that, so far as vegetable sources of raw material and the manufacture of power alcohol were concerned, Great Britain must rely mainly, if not entirely, on increased production in tropical and sub-tropical countries.

Power alcohol is a fuel of particular merit in that its supply is *absolutely inexhaustible*.

Petrol and Power Alcohol Compared.

On the basis of available combustible matter, petrol is a better fuel for engines of the present-day design than alcohol, since high-grade petrol may contain 135,000 B.t.u. per gallon whereas power alcohol only contains approximately 84,450 B.t.u. The low absorption of water by petrol, in contrast to the miscibility of water and alcohol in all proportions, is perhaps a further disadvantage although not in the case of accidental fire. Nevertheless, there are certain physical characteristics of power alcohol which are much more favorable than those of petrol.

It has been claimed that the use of power alcohol or power alcohol blended with petrol results in a lower relative mileage and power output, as compared with straight petrol. Because of the lower calorific value of alcohol, the claim is undoubtedly true for unadulterated alcohol, and would be true for alcohol blends, if the efficiency of the internal combustion engine depended solely upon the potential energy of the fuel. This, however, is not the case. The actual power and mileage of which an engine is capable, is the result of compression, carburetor setting, spark adjustment, engine temperature, volatility of fuel, speed, acceleration and design, all of which are complicated by other factors such as method of driving, load, grade of road, &c. It is the total effect of all these factors which determines the mileage and power a fuel is capable of producing.

Much data has been published on the subject of mileage and Bridgeman (1936) has summarized the results of various findings as follows:—

> " When used in the same engine, particularly with the carburetor and spark set for the mean of the optimum values for the two types of fuels, little difference in power, acceleration, or fuel consumption is observed with a 10 per cent. blend, or even with a 20 per cent. blend under many operating conditions."

He also states—

> " If suitably designed engines are used for the two types of fuels, equal or better power and acceleration per gallon of fuel consumed may be obtained from the blend when comparing a petrol and the same petrol blended with ethyl alcohol, within the range of present-day petrols."

In a recent publication on " Effects of Different Carburetor Settings on the Performance Characteristics of some makes of Automobile Engines using Alcohol as Motor Fuel ", Teodoro (1940) summarizes the results of his findings as follows:—

> " 1. With petrol as fuel the differences in fuel consumption between optimum economical carburetor setting and maximum power setting are approximately 5 to 8 per cent. at full throttle and 1 to 3 per cent. at fractional loads. The difference in power developed hardly exceeds 3 per cent. Detonation was more evident in adjustments giving lean mixtures than those giving rich.
>
> 2. Maximum power setting with nearly straight alcohol gave about 10 per cent. more power than the maximum that could be developed with petrol. This was done at the expense of a fuel consumption ratio (compared with petrol by weight) varying from 1.4: 1 to 1.7: 1. It was easily possible to double the consumption of alcohol without increasing the power developed when a certain maximum load was reached.
>
> The most economical adjustment that could be obtained was one giving a fuel consumption ration of 1.27: 1 (compared with petrol by weight) and a maximum load of about 5 per cent. less than the standard set by the engine manufacturer.
>
> There was no evidence of detonation when nearly straight alcohol was used.
>
> 3. The 10 per cent. alcohol-petrol mixture gave as efficient running as petrol and developed about 5 per cent. more power with the same economical adjustment. With medium setting, the engine not only developed 10 per cent. more power but also consumed 5 to 7 per cent. less fuel than petrol.
>
> 4. The 20 per cent. alcohol-petrol mixture gave less fuel consumption than petrol at economical setting but developed about 3 per cent. less power. The difference in fuel economy varied from 3 per cent. to as high as 20 per cent. depending upon the jet used.
>
> 5. There was no evidence of detonation when the alcohol-petrol mixtures were used under any carburetor settings. Acceleration was slightly sluggish when the 20 per cent. mixture was tested with the most economical jet.
>
> 6. Better results in fuel economy and power were obtained with alcohol and alcohol-petrol mixtures at a high compression ratio. Petrol, on the other hand, detonated badly, developed less maximum power, but gave slightly better fuel economy at certain loads with a high compression ratio than with low.
>
> 7. The present trend of compression ratio used in automobile engines favours the utilization of alcohol and alcohol-petrol mixtures as fuel."

Comparing petrol with straight alcohol, Cook (1927) writes—

> " By the use of high compression engines, therefore, it is possible to obtain from alcohol about the same work and hence about the same mileage per gallon as it is possible to obtain with petrol in lower compression engines."

It is thus seen that, in present day engines with the carburetor suitably adjusted, a 10 per cent. alcohol-petrol blend is superior to straight petrol. With a 20 per cent. blend there is a small loss of power with a slightly higher petrol consumption. There is no detonation when either mixtures is used. If straight alcohol is used, a high compression engine will give more power than a low compression engine.

Some investigators have reported poor starting in cold weather from certain alcohol-petrol blends. On this point Bridgeman (*loc. cit.*) wrote—

> "When comparing petrols with the same petrols containing 10 per cent. alcohol, engine starting will be easier with the blend at temperatures above 0° F. and will be more difficult with the blend at temperatures below —10° F., with little difference in the intermediate range. The conclusions are not changed when the blend has the same vapour-locking tendency as petrol."

Bridgeman concludes—

> "When used in the same engine, a 10 per cent. blend is more likely to give trouble from vapour lock than the petrol (alone) with which the alcohol is blended. Little difference would be expected with a 20 per cent. blend, and the situation would be reversed with a 40 per cent. blend, since there is greater freedom from vapour lock difficulties with the blend than with the petrol, from which the 40 per cent. blend was prepared. Addition of alcohol in increasing quantities first increases and later decreases the Reid vapour pressure. The same (comparative) freedom from vapour lock may be obtained for a 10 per cent. blend and petrol if the vapour pressure of the petrol used (for blending) is lower than that of the petrol with which the blend is compared."

According to Cook (*loc. cit.*) and others, the use of power alcohol or alcohol-petrol blends, calls for the use of a higher compression ratio than the same unblended petrol.

It is Bridgeman's (*loc. cit.*) opinion that—

> "No material gain in engine performance is obtained by the increase in octane number on blending unless the compression ratio of an engine is sufficiently high to take advantage of the increased octane number."

Ogston (1937) and Nash and Howes (1935) concur in the above opinion.

The effect on the octane rating of petrol resulting from the addition of power alcohol is summarized in the following statement by Bridgeman (*loc. cit.*) :—

> "The octane number of pure ethyl alcohol is about 90 (on the basis of present test methods) while that of petrol varies from about 74 to 80 for the first grade; about 65 to 70 for the second grade; and usually below 65 for the third grade. Accordingly, blending ethyl alcohol with petrol will improve the octane number by amounts which cannot be stated quantitatively but which depend upon the percentage of alcohol used and upon the octane number of the petrol. In general, addition of 10 per cent. of ethyl alcohol to a second or regular grade of petrol will increase the octane number about three to five units, while the increase will be less when blending with the first or premium grade, and may be as high as 10 octane units when blending with a low, third grade petrol. As a result of this increase in octane number, it is possible to use for blending, a petrol of lower octane number than would be used unblended."

Ogston (*loc. cit.*) states—

> "It can, no doubt, be accepted that, at any rate with fuels between 65 and 85 octane numbers, an increase of one octane number will permit an increase of about 1 per cent. engine efficiency, always provided that the engine has been properly designed to take full advantage of the higher antiknock value. Now, although the alcohol response of different petrols varies a good deal, as a general rule it can be accepted that when ratings between 65 and 85 octane are being dealt with, the addition of 1 per cent. ethyl alcohol increases the knock rating of the petrol by at least 0.7 octane number. Thus a 15 per cent. blend results in a loss of 5 per cent. calorific value, but the octane rating would have been increased by at least 10, which will accordingly permit an increase in efficiency of about 10 per cent. It is evident from this that alcohol therefore, more than 'pays its way', since its lower calorific value is offset by the higher efficiency which it is possible to obtain by better octane rating in the ratio of loss to gain of about 1 to 2. The inclusion of benzol, of course, still further improves the picture."

Nash and Howes (*loc. cit.*) state—

> "The antiknock value of ethyl alcohol has been recognized for some years and has not been disputed."

The latent heat of vaporization of ethyl alcohol is 209 calories per gram, as compared with 75 calories per gram for petrol. The boiling temperature of ethyl alcohol is approximately 173° F., whilst that of petrol ranges from 100° to 400° F. It is thus seen that when using a fuel containing ethyl alcohol, an engine operates at a cooler temperature than when using ordinary petrol and thus operates more efficiently.

In conclusion, we may quote the words of Cole (1922), who gave the matter much consideration:—

> "Alcohol mixtures to-day are being used on a large scale in the present type of petrol engine with simple alterations. These mixtures offer many advantages and no disadvantages over petrol and are more efficient than petrol."

Magnitude of Possible Markets.

Recent communications from Canberra indicate that, at present, there is a good market for power alcohol in Australia. Support is given to this statement by the recent introduction of a petrol rationing scheme. However, this may be only a temporary, war-time market, and it would be irrational to invest capital in a plant for the production of power alcohol to satisfy a temporary market unless the need were most urgent.

An indication of the market, which is likely to exist at the termination of the war, is best obtained by investigating the market which existed before the present disturbed state of affairs. The amounts of petrol imported into New Guinea and Australia during the five years preceding the commencement of the war, are given in Table I.:—

TABLE I.—PETROL CONSUMPTION IN NEW GUINEA AND AUSTRALIA.

—	1934–35.	1935–36.	1936–37.	1937–38.	1938–39.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
New Guinea	823,920	1,060,078	870,279	1,087,440	937,708
Australia..	267,632,864	319,336,547	341,547,869	402,979,165	399,517,906

From Table I., it is seen that the normal petrol consumption in New Guinea is approximately 1,000,000 gallons, and in Australia over 300,000,000 gallons per annum. It is thus considered that 300,000,000 gallons per annum may be taken as a conservative estimate of the petrol requirements in New Guinea and Australia in normal times.

Alcohol has been successfully blended not only with petrol but with many other substances, notably ether and benzol, for use as a fuel in the modern type of automobile engine. The constituents of the more popular blends are given in Table II. together with the approximate amounts of alcohol which would be required if legislation were to enforce their use in New Guinea and Australia.

TABLE II.—PETROL BLENDS AND ALCOHOL REQUIREMENTS.

Blend. No.	Blend. Constituents.	Blend. Per cent.	Where Marketed or First Used.	Approximate Market in Australia and New Guinea. Gallons.
1	Alcohol	5	Alcohol-petrol blends are marketed in practically every country in the world	15,000,000
	Petrol	95		
2	Alcohol	10		30,000,000
	Petrol	90		
3	Alcohol	15		45,000,000
	Petrol	85		
4	Alcohol	20		60,000,000
	Petrol	80		
5	Alcohol	40	United States.. ..	120,000,000
	Petrol	35		
	Benzol	25		
6	Alcohol	40	United States.. ..	180,000,000
	Petrol	35		
	Ether	25		
7	Alcohol	70	Australia	230,000,000
	Petrol or Benzol ..	20		
	Ether	10		
8	Alcohol	55.55	Hawaii	300,000,000
	Ether	42.78		
	Kerosene	1.11		
	Pyridine	.56		
9	Alcohol	55	South Africa	300,000,000
	Ether	44.9		
	Ammonia	.1		
10	Alcohol	80 gals.	.. .. ..	240,000,000
	Benzol	20 gals.		
	Naphthalene	2 lb.		

Blends 6, 7, 8 and 9 contain ether. Ether can be readily and cheaply manufactured from alcohol by what is known as the "continuous etherification process". The alcohol is mixed with sulphuric acid and heated, an alkyl hydrogen sulphate being formed. On addition of more alcohol, the latter is decomposed, forming ether and regenerating sulphuric acid. The sulphuric acid then forms more of the alkyl hydrogen sulphate, which with more alcohol again forms ether, and were it not for the destruction and dilution of the acid by the products of side reactions, a given quantity of sulphuric acid could transform an unlimited quantity of alcohol into ether.

Ricardo (1924) has investigated the effect of small amounts of ether in alcohol fuel mixtures from the point of view of their behaviour in a Leyland lorry engine at various positions of the throttle. His general conclusions in this connexion are as follows:—

> "1. Both at half load and at quarter load there is a definite advantage as regards power, economy, and range of combustion due to the addition of small proportions of ether in alcohol mixtures.
>
> 2. These advantages become well marked for the 10 and 15 per cent. ether mixtures. The increase in range of combustion giving increased "responsiveness" in acceleration is clearly shown.
>
> 3. Between alcohol alone and a mixture containing 10 per cent. ether the improvement in efficiency was measured as 7.5 per cent. both for half-load and for quarter-load conditions.
>
> 4. At half-load the efficiency on petrol was no less than 12 per cent. higher than for the most economical of the alcohol-ether mixtures."

It is pointed out, howover, that the above results apply to an engine running at a constant speed whereas ordinarily the speed of the engine would be by no means constant.

In blends 6 and 9, benzol is a constituent. Benzol (benzene) is manufactured from coal-tar, about 2.5 gallons of rectified benzol being obtained from the high temperature carbonization of 1 ton of coal; naphthalene is also manufactured from coal-tar.

Pyridine or ammonia is added to blends 8 and 9 to neutralize any acid which might be formed in the fuel or in the combustion of the fuel. It also serves as a denaturant.

In a consideration of the amount by which petrol importations should be reduced, consideration must not only be given to technical aspects but to matters of national defence, international trade and internal economics. From Table II. it is seen that blends 8 and 9, neither of which contain petrol, would open up the largest market for power alcohol. Such blends would be a considerable help in conserving petrol supplies, would give employment to a large number of people, would make Australia less dependent on other countries, but would however upset our international trade somewhat. On the other hand, a petrol blend containing only a small percentage of alcohol (e.g. No. 1 blend) would result in a very small conservation of resources, would give little extra employment, and it would still be necessary to import large quantities of petrol. When, after consideration of all these factors, a figure has been decided upon, it would then be necessary to establish a market. With the present shortage of petrol in Australia, this would not be difficult although, as a safeguard, it would probably be advisable to introduce legislation compelling importers to purchase power alcohol amounting to a definite fraction of the petrol they import. With constant and regular supplies of power alcohol available and this alcohol blended to produce a fuel cheaper and equal, if not superior to petrol, it is unlikely that there would be trouble in retaining a market for the product.

In Queensland, all petrol companies are required by law to purchase a quantity of pure alcohol equal to 1.5 per cent. of the volume of petrol brought into the State. There is no law or regulation requiring the use of alcohol as a constituent part of the petrol sold, but the petrol companies, in order to dispose of the alcohol they are forced to purchase use it for blending with petrol to make distinct grades of motor fuel. It is reported that some time ago there was an organized effort to have the Government compel the petrol companies to use alcohol to the extent of 15 per cent. of the volume of imported petrol.

In Victoria, at least one independent oil company has been marketing an alcohol-petrol blend for over four years during which time millions of gallons have been sold. Similar blends are also probably sold in all other States of the Commonwealth. The blends are particularly popular with motor cycle and car racing experts.

In England, alcohol blends can be sold at the same market price as first-class petrol. The methylated spirit regulation of 1930, ruled that alcohol used in internal-combustion engines should be tax-free, provided that it was blended with a minimum of 25 per cent. petrol or benzol, whereas straight petrol paid a tax of 8d. per gallon. In addition, under the Revenue Act of 1906, motor fuel alcohol received a Government allowance of 5d. per proof gallon, or 8¾d. per Imperial gallon. In May, 1938, the tax on petrol was increased to 9d., and this also became effective on alcohol blends. In 1934, Government factories in the Irish Free State were authorized to produce motor fuel from potatoes. This alcohol is exempt from tax if used in motor fuel blends (10 per cent.).

Summing up, the foregoing information indicates that a large market awaits development in Australia, and possibly Great Britain for cheap power alcohol. The extent and ultimate success with which such a market could be established, however, would probably depend on suitable legislation fostering its initial stages of development, otherwise, there would be a chance of the market never becoming properly established and collapsing at the termination of the war. Such legislation, besides stimulating industrial activity and giving employment, would foster the local production of an essential commodity for which Australia is, at present, largely dependent upon foreign countries.

Sources of Alcohol.

In evaluating the economic possibility of successfully making power alcohol from agricultural products, it is necessary not only to know the extent of the possible market which could be developed but the amount and distribution of suitable raw material which is available or could be made available when required. Problems of planting, harvesting, collecting, transporting and storing without serious deterioration, especially in the case of perishable materials, would have to be investigated. Technical problems of processing would also have to be solved. The net price that could be paid for the raw material, its value in comparison with other raw materials, the cost of producing the alcohol and the selling price such a product could command on the basis of comparative efficiency as a motor fuel, are other essential factors in the undertaking which should be considered. Above all, it must be remembered that the situation is continually changing and that a consideration of the problem should include future as well as present conditions.

Power alcohol may be derived from three classes of agricultural products—

(1) Saccharine materials (molasses, sugar beet, nipa palm, &c.).
(2) Starchy materials (grains, potatoes, cassava, sago palm, &c.).
(3) Cellulosic materials (wood, sulphite liquor from paper pulp mills, &c.).

At present, the chief source of ethyl alcohol is sugar-cane molasses, which are the waste syrup remaining after the commercial extraction of crystallized sugar from evaporated sugar-cane juice. This material has been the main source of ethyl alcohol for a great many years. It has an advantage over starchy materials in that its carbohydrate is already in a suitable form for transformation into alcohol by the action of yeast, whereas starch-bearing products must be treated with diastase or dilute acids to convert the starch into sugar before fermentation can take place. The feasibility of producing power alcohol from other products largely depends on the availability and suitability of each raw material.

In New Guinea and Papua, there are three good sources of raw material for the large-scale production of power alcohol. They are cassava (*Manihot utilissima*), the sago palm (*Metroxylon sagus* and *M. rumphii*) and the nipa palm (*Nipa fruticans*).

In 1922, it was shown by Cole that the sap of the nipa palm was the cheapest source of alcohol in the world, namely, .027 dollars per litre of 180 proof or 90 per cent. alcohol, estimating the raw material as delivered at the distillery. Cassava was the second cheapest source, being .034 dollars per litre. Prices have changed considerably since these costs were computed, but the list of available raw materials is practically the same, and by giving the materials present-day prices it is seen that nipa palm sap and cassava roots are still probably the cheapest source of power alcohol. No reference can be found in the literature to the use of the sago palm for the production of alcohol.

In some countries the coco-nut palm (*Cocos nucifera*) is cultivated for its sap, from which an alcoholic beverage is made. There is more labour involved in obtaining the sap from the coco-nut palm than from the nipa because of the height of the palms. To facilitate collection, bamboo poles are usually attached from palm top to palm top, forming bridges upon which the collector can travel without descending to the ground until his receptacle is full.

Since the coco-nut palm blossoms throughout the year, the sap-collecting season is continuous, and when one stalk is exhausted another is tapped. The average daily yield per palm is approximately one-sixth of a gallon. The sap has approximately the same sugar content as nipa palm sap, so that, volume for volume, the yield of alcohol would be approximately the same. It is thus seen that the coco-nut palm is a possible source of power alcohol. However, such a source would be most undesirable in this territory, for once the native learnt to tap coco-nut palms, which are to be found everywhere, he would soon acquire a taste for the fermented sap and intoxication would be difficult to prevent in the villages. On the other hand, the restricted growth of the nipa palm makes control measures a comparatively simple matter.

CASSAVA (MANIHOT UTILISSIMA).

Cassava or tapioca, although now grown throughout the tropics, is indigenous to South America. It grows in many parts of this territory, although there are no records indicating when it was first introduced here.

Description.—The cassava plant is a small, shrubby perennial, attaining a height of 6 to 8 feet, and has large tuberous roots which contain a high percentage of starch. There are said to be at least 40 varieties, falling into two groups—"bitter" and "sweet". The roots of bitter cassava contain a cyanogenetic substance, which, on decomposition, yields prussic acid. This is rendered inert by cooking. Sweet cassava, generally supposed to be free from this poison, actually contains small quantities in the rind and outer layers of the tubers.

Habitat and Available Areas.—Although cassava is to be found growing in many parts of the territory, it is generally grown as a native food crop, and if large quantities were required for the production of power alcohol, fresh areas would have to be planted up.

The best soil for growing cassava is a light, rich, sandy loam and many growers prefer that such a soil should be underlaid by a hard pan, which will prevent the roots from going too deep into the ground. The soil should be dry rather than wet and fair yields can be secured from soils too dry for many other crops. Recently-cleared land appears to be preferred by the natives, as it is rich in plant food and the crop can be grown on it continuously for several years with good yields. Swampy soils and heavy black soils, excessively rich in humus, should be avoided, for in the latter case the plant makes much top growth but the tubers are small. Heavy clay soils are also unsuitable, as they give low yields and the roots are difficult to dig.

The cassava plant is always propagated commercially by means of stem cuttings. In some varieties seeds are never or rarely formed, but even when available, they should never be used, as the plants raised from them always give low yields of roots. Only the middle portions of well-matured, vigorous stems should be used for propagation, the basal, woody part and the extremities of the branches being discarded. The cuttings should not be made until they are required for planting, and should be about 8 or 10 inches long. Only living stems, distinguished by their plump appearance, fresh-looking bark, sound pith and plump buds, should be used. Stems which appear shrivelled, are bleached or darkened in colour, have discoloured or dry pith and shrunken buds, should be rejected. The ends of the cuttings must be cut cleanly. This may be done with a sharp, heavy knife.

Before planting, the soil must be brought into a fine state of tilth. This may be done by hoeing, ploughing or harrowing. It is advisable not to plough too deeply so that the roots may be kept nearer the surface and be easier to dig.

Newly-cleared land will not, as a rule, require manuring, but land which has been under cultivation may have to be enriched by this means. Potash is the chief food constituent taken up by the cassava roots, and as potash salts favour the formation of starch and sugar, it is essential that this constituent be present in sufficient quantity. Large quantities of available nitrogen in the soil induce an excessive growth of stems and leaves without a corresponding increase in the yield of roots. If a leguminous crop, such as velvet beans or cowpeas, has preceded cassava, a practice to be much recommended, a nitrogenous manure will not be necessary and a mixture consisting of 200 lb. of kainit and 300 lb. of superphosphate per acre may be used. The exact amount to be applied will depend upon the nature of the soil; more should be used on poor soils, whilst on calcareous soils the amount of superphosphate may be less. If nitrogen is to be added, it may be applied conveniently in the form of nitrate of soda at the rate of 250 lb. per acre. The potassic and phosphatic manures should be added before the crop is planted and the nitrogenous manure just after growth has commenced. If chemical manures are not available, about 8 to 10 tons of animal manure per acre, preferably mixed with wood or coco-nut shell ashes, may be used.

Copeland (1931) regards cassava as the best catch crop for planting with coco-nuts until the latter begin to bear. It is also used as a catch crop with young rubber and as a temporary shade for young coffee and cocoa.

Yields.—The yield of cassava roots is dependent upon the variety, fertility of the soil, climate, cultivation, vitality of the cuttings, number of plants per acre, and the age of the plants. Typical annual yields in New Guinea are about 10 tons to the acre, although yields of nearly 25 tons have been obtained.

Table III., compiled by Galang (1931) in the Philippines, gives reported yields per acre of tubers in different countries.

Taking the mean of the figures in this table, it is seen that the yield varies from about 10 to 38 tons per acre. The New Guinea figure (10 tons) is on the lower limit of this range and could undoubtedly be increased.

TABLE III.—CASSAVA YIELDS IN DIFFERENT COUNTRIES.

Country.	Tons per Acre.
Caledonia	10 to 100
East Africa	1 to 90
Florida	30 to 40
Jamaica	3 to 13
Java and Ceylon	10
Virgin Islands	8 to 46
Hawaii	16 to 30
Trinidad and Tobago ..	3 to 10
Barbodos	6 to 10
Laguna	12 to 35

The results given in Table IV. were obtained from a series of experiments carried out at the Hope Agricultural Station in Jamaica and give the yields of different varieties of cassava at different stages of maturity. It appears to be advantageous to harvest the crop at 21 months—

TABLE IV.—CASSAVA ROOT YIELDS.

Variety.	Yield of Roots.			Quantity of Starch in Roots.		
	At Twelve Months.	At Fifteen Months.	At Twenty-one Months.	At Twelve Months.	At Fifteen Months.	At Twenty-one Months.
	Tons per acre.	Tons per acre.	Tons per acre.	Lb. per acre.	Lb. per acre.	Lb. per acre.
Blue Top	8.25	14.2	21.9	5,636	9,733	15,818
Black Stick	6.5	6.5	18.0	4,878	5,197	15,433
Smalling	7.5	11.1	19.3	5,494	8,553	13,883
Mullings	5.75	11.1	18.0	4,160	8,180	13,277
Long Leaf—Blue Bud ..	9.0	15.4	15.4	6,552	12,857	13,187
White Top	10.5	11.0	11.6	7,902	7,638	8,753
Luana Sweet	6.75	8.1	9.0	5,322	6,540	7,102
Rodney	7.5	9.7	10.3	5,337	6,931	6,547

Cousins (1915) has determined the starch content of a number of bitter and sweet varieties of cassava grown in Jamaica and the average results calculated from his figures are given in Table V. There is little difference in the starch contents of the two varieties.

TABLE V.—STARCH CONTENT OF BITTER AND SWEET VARIETIES OF CASSAVA.

—	Bitter Varieties.		Sweet Varieties.	
	Moisture.	Starch.	Moisture.	Starch.
	Per cent.	Per cent.	Per cent.	Per cent.
After twelve months' growth—				
Fresh	58.4	32.9	58.4	31.8
Dry	..	79.1	..	76.4
After fifteen months' growth—				
Fresh	60.9	32.5	61.0	32.6
Dry	..	83.1	..	83.6
After twenty-one months' growth—				
Fresh	59.4	34.2	60.2	34.7
Dry	..	84.2	..	87.3

In Table VI. typical figures are given for the composition of cassava roots and potatoes. Potatoes are used extensively for the production of power alcohol in Germany and other European countries. It is seen that cassava contains considerably more fermentable material than potatoes. A high-grade root would contain over 30 per cent. starch and 6 per cent. sugar. Even if the average content of total fermentable matter be taken as 25 per cent., which is a very conservative estimate, this amount would be much greater than that in potatoes. The dry roots contain about 90 per cent. of fermentable substances and are a much more valuable source of alcohol, weight for weight, than any other material mentioned in Table VII.

TABLE VI.—COMPOSITION OF CASSAVA ROOTS AND POTATOES.

Constituent.	Cassava Roots.		Potatoes.	
	Fresh.	Dry.	Fresh.	Dry.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	65.25	..	75.80	..
Protein	1.12	3.22	2.08	8.59
Fat	0.41	1.18	0.20	0.83
Starch	26.45	76.08	19.90	82.23
Sugar	5.13	14.76		
Fibre	1.11	3.22	1.10	4.55
Ash	0.54	1.54	0.92	3.80

In *Motor Fuels from Farm Products* (1938), a recent publication of the United States Department of Agriculture, information is given on the quantity of alcohol obtainable from various raw materials. This information is embodied in Table VII.

TABLE VII.—ALCOHOL YIELDS FROM VARIOUS CROPS.

Order.	Material.	Fermentable Matter.		Yield of 99.5 per cent. alcohol/ton in gallons.	Approximate yield of 99.5 per cent. alcohol/acre in gallons.
		Per cent.	Pounds/ton.*		
1	Cassava	30.0	672	48.7	487
2	Sugar beet	16.0	358	24.8	321
3	Sugar cane	11.0	246	17.0	300
4	Jerusalem artichoke ..	15.2	340	22.4	202
5	Potatoes	15.6	349	25.6	199
6	Sweet potato	23.3	522	38.3	158
7	Apple	11.0	246	16.1	157
8	Date, dry	60.0	1,344	88.5	141
9	Carrot	7.5	168	11.0	136
10	Raisin	62.0	1,389	91.2	114
11	Yam	18.7	419	30.6	105
12	Grape (all varieties) ..	11.5	258	16.9	101
13	Corn	57.8	1,295	94.1	100
14	Peach	8.7	195	12.9	94
15	Prune, dry	55.0	1,232	80.6	93
16	Pineapple	11.9	267	17.5	87
17	Rice, rough	54.6	1,223	89.0	74
18	Pear	8.9	199	12.9	55
19	Barley	54.3	1,216	88.7	54
20	Molasses, blackstrap ..	51.0	1,142	78.8	50
21	Apricot	10.4	233	15.2	46
22	Grain Sorghum	54.5	1,221	88.9	40
23	Oats	43.6	977	71.2	40
24	Buckwheat	57.2	1,281	93.3	38
25	Wheat	58.6	1,313	95.2	37
26	Fig, fresh	16.0	358	24.6	36
27	Fig, dry	45.0	1,008	66.1	34
28	Rye	54.0	1,210	88.3	27
29	Plum	8.3	186	12.2	25

* = 2,240 lb.

From Table VII. it is seen that the highest yield of 99.5 per cent. alcohol per acre is obtained from cassava, being 487 gallons. Sugar beet gives the next highest yield and sugar cane the third highest. The yield from potatoes is less than half that from cassava.

In compiling Table VII., it has been assumed that in each case alcohol recovery will be 85 per cent. of the theoretical yield, calculated on the part of the material naturally fermentable by yeast. In commercial practice, this would be exceeded in most cases. In general, yield figures, which are calculated on the basis of the carbohydrates (less pentosans) present, are conservative values.

Alcohol Production.—The method of obtaining alcohol from cassava tubers does not differ appreciably from that used in the case of other similar materials, such as potatoes. There are three principal steps:—(1) Preparation of mash or wort; (2) Fermentation by means of yeast of the mash drawn off from the mash tun; (3) Distillation of the dilute alcohol formed in the beer or wash from the fermentation tanks.

Mashing.—The cassava is first softened by steaming and then gradually broken up and mixed with water to reduce the starch in the raw material to a thin paste in order that the malt ferment, subsequently added, may act upon it readily and convert it into sugar.

The conversion of starch into a fermentable sugar may also be accomplished without the intervention of malt. This is done by heating the raw material with dilute acid under pressure when it is largely converted into glucose, which can be fermented directly by yeast.

Fermentation.—The mash, after the starch has all been converted into sugar, is passed into fermenting tanks and the yeast added. These tanks often have a stirring apparatus with which the contents are thoroughly mixed with the yeast and kept in motion. This is not necessary after the fermentation is well established, but it is advisable, especially in the early stages, to keep the yeast well distributed throughout the mass. In these tanks the temperature is varied according to the nature of the product to be made. In making power alcohol, the sole object is to secure the largest possible percentage of alcohol at the lowest possible cost without reference to its potable properties or odour.

Distillation.—The object of this process is to separate the alcohol contained in the fermented liquor from the non-volatile products and water with which it is mixed. The stills in use for this purpose are of numerous types and their structure and method of action are too complicated to be discussed here, but, in general, it may be said that they are so arranged as to permit of a current of steam being driven through a falling column of the fermented liquor, which is thus gradually deprived of its alcohol, the latter being carried off by the current of steam which gradually becomes richer and richer in alcohol until finally, on condensation, it yields alcohol of the required strength.

Alcohol that is to be mixed with petrol for use as a motor fuel should not contain more than a few tenths of 1 per cent. water. When ordinary 95 per cent. alcohol is mixed with a much larger proportion of petrol at low temperatures, the mixture is likely to separate into two layers unless certain blending agents, or mutual solvents, such as butyl alcohol, benzol, or acetone, are added. Anhydrous alcohol mixes with petrol in all proportions and at practically all temperatures.

Commercial processes and equipment have been developed for obtaining alcohol in a nearly anhydrous condition from ordinary high proof alcohol, or directly from the fermented mash. Many of these processes and the essential equipment are patented, and during the life of the patents can be used only under licence. They include—

(1) Azeotropic distillation methods, which are dependent on the fact that when suitable organic liquids, such as benzol, trichloroethylene, or volatile mineral spirits are mixed with high strength alcohol during distillation, the water present, with a small proportion of the alcohol, is distilled over; the excess of the azeotropic agent then distills out, leaving the rest of the alcohol in an anhydrous state.

(2) Use of anhydrous materials, such as potassium or sodium alcoholate, potassium or sodium acetate, aluminium or calcium oxides, or calcium sulphate, to absorb water from a vapour mixture of alcohol and water.

(3) Distillation of the alcohol under a partial vacuum.

Present methods of power alcohol production generally produce the alcohol in a comparatively pure form first and then it is intentionally contaminated or denatured before being marketed. Although power alcohol should contain only small amounts of water, it may contain considerable amounts of other impurities without its value being considerably impaired and, since such alcohol must also be produced very cheaply, initial purification with subsequent denaturation appears to be an unnecessary expense. Thus the manufacturing process could be undoubtedly simplified if power alcohol were the only product manufactured.

The conventional alcohol process is schematically depicted in Figure I., which shows the different steps as well as the daily requirements of each.

Quite recently, moulds have been discovered which are able both to saccharify starch and ferment the resulting sugars. They thus eliminate one step in the above process. This new process has been employed with considerable success in some countries and could possibly be used to advantage in New Guinea.

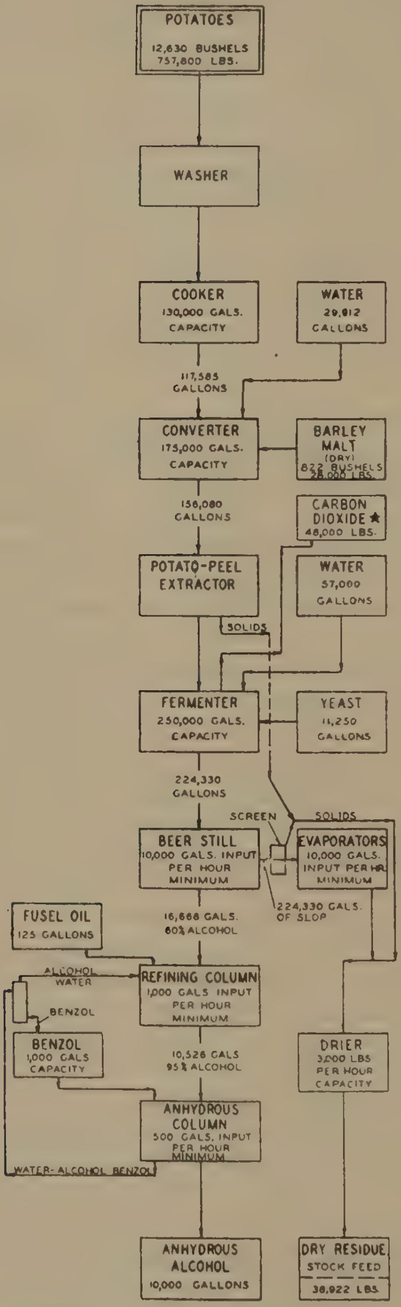
THE SAGO PALM (*Metroxylon sagus* and *M. rumphii*).

The two important species of *Metroxylon* are *M. sagus,* the smooth-sheathed sago palm, and *M. rumphii*, the spiny-sheathed sago palm. Both are found in New Guinea. The latter is a slightly smaller palm than the former, but both are so alike that they will be treated together. The spiny species has a somewhat shorter trunk and a lower yield of starch.

Description.—The sago palm is a pinnate-leafed palm, the leaves being 20 or more feet in length. It reaches a height of 30 to 40 feet and has a short cylindrical trunk having a girth of 50 to 60 inches from which is obtained the sago of commerce. The palm reaches maturity in about twelve years and, after fruiting, dies.

Habitat and Available Areas.—The sago palm thrives in New Guinea and Papua where it may be found growing in all coastal districts. It is most abundant in low-lying land at the mouths of rivers and grows best in swamps where it would be almost impossible to grow any other crop. The most extensive areas in New Guinea are in the vicinities of the Sepik and Ramu Rivers and in the Aitape

FIGURE I.


POTATOES
12,630 BUSHELS
757,800 LBS.
WASHER
COOKER
130,000 GALS.
CAPACITY
WATER
29,812
GALLONS
117,585
GALLONS
CONVERTER
175,000 GALS.
CAPACITY
BARLEY
MALT
(DRY)
822 BUSHELS
28,000 LBS.
158,080
GALLONS
CARBON
DIOXIDE ★
48,000 LBS.
POTATO-PEEL
EXTRACTOR
WATER
57,000
GALLONS
SOLIDS
FERMENTER
250,000 GALS.
CAPACITY
YEAST
11,250
GALLONS
224,330
GALLONS
SCREEN
SOLIDS
BEER STILL
10,000 GALS. INPUT
PER HOUR
MINIMUM
EVAPORATORS
10,000 GALS.
INPUT PER HR.
MINIMUM
224,330 GALS.
OF SLOP
FUSEL OIL
125 GALLONS
16,668 GALS.
60% ALCOHOL
ALCOHOL
WATER
REFINING COLUMN
1,000 GALS INPUT
PER HOUR
MINIMUM
BENZOL
BENZOL
1,000 GALS
CAPACITY
10,528 GALS
95% ALCOHOL
DRIER
3,000 LBS
PER HOUR
CAPACITY
ANHYDROUS
COLUMN
500 GALS. INPUT
PER HOUR
MINIMUM
WATER-ALCOHOL BENZOL
ANHYDROUS
ALCOHOL
10,000 GALLONS
DRY RESIDUE
STOCK FEED
38,922 LBS.

★ RECOVERABLE AS SOLID CARBON DIOXIDE

From "Motor Fuels from Farm Products."

District. Starch obtained from the trunk of the sago palm is used in many Districts as a native food although often only when the taro crop fails. In some areas, the starch content of the palms is so low that the natives do not consider them worth working. Such areas, however, could be eventually planted up with selected material from high yielding palms.

The sago palm may be propagated either from seed or suckers. Unless suckers are most carefully removed from the parent palm, they will not survive after being planted out. On the other hand, there is a considerable advantage to be gained by planting seeds in nurseries and transplanting the seedlings when about twelve to eighteen months old. Not only is this method less expensive, but the results generally prove to be far more satisfactory.

Care should be taken in the selection of the seed to avoid the " spiny " types. This leads to a difficulty when growing from seed, as they do not always breed true and hybrid spiny types may be produced. The difficulty may be overcome by selecting the seedlings before planting out.

The seeds in the husk are planted about one foot apart in slightly raised nursery beds and shaded until they bear three leaves. They should be ready for planting in the field after twelve to eighteen months. The area to be planted should be cleared, and holes dug for the seedlings about 15 feet by 15 feet apart, giving 193 palms to the acre. For one or two years the plants should be circle weeded and any undergrowth cleared sufficiently to prevent interference with the growth of the palms; after this period, little attention will be required. After nine or ten years, when the palms begin to flower their starch content is at a maximum and they may be cut down. About 50 trees per acre will mature about the ninth year, after which an annual crop of 50 trees per acre may be expected, as those cut down will be replaced by suckers produced from the roots of the original palms.

In a dense area of wild sago palms, the number of trees per acre have been estimated at 2,000–1,500 of which at least 100 may be expected to reach maturity each year. Because of the density of growth, the size and starch content of these palms is low but could probably be increased by thinning out. The starch content of an average " smooth-sheathed " palm growing under fair conditions is about 300 lb. although a particularly large palm may yield 1,200 lb. of starch. A conservative estimate for a wild palm would probably be 250 lb. per palm or an annual production of 11 tons to the acre. On a plantation where the palms were grown from selected seed, the yield would be much higher than this amount. A yield of 11 tons will be used during later computations.

In order to work the areas of wild sago palms in this Territory, it would be first necessary to thin them out so that all palms are accessible. This would mean a considerable loss of palms but, as already pointed out, this loss would probably be more than compensated for by the increase in size, and thus yield, of the remaining palms.

When the palms reach the flowering stage they contain a maximum amount of starch and are ready for felling. The native method of extracting the starch (*see* illustrations) would be too slow and expensive for the large scale production of alcohol, and special machinery would be required for the disintegration of the trunk. After the palm is felled, the trunk could be cut into convenient lengths of about 3 feet for transportation to the factory. A considerable reduction in weight could be introduced by removing the outer layer of bark before transhipment, although the slight loss of starch and the extra time involved in removing the bark by hand may not favour the step.

From analyses carried out in this laboratory on a typical sago palm, the interior of the trunk was found to have the following composition:—

Water	52 per cent.
Protein	2 „ „
Fat	0.5 „ „
Sugar and starch	26.8 „ „
Fibre	18.0 „ „
Ash	0.7 „ „

These figures indicate that at least 25 per cent. of the interior of the trunk consists of fermentable material, or 560 lb. per ton. This would yield approximately 40 gallons of 99.5 per cent. alcohol per ton, that is, 440 gallons of 99.5 per cent. alcohol per acre. Comparing these figures with those given in Table VII, it is seen that the sago palm is a better source of power alcohol than any of the materials listed, with the exception of cassava.

After the material has arrived at the factory and has been suitably disintegrated, the steps for the manufacture of alcohol would be exactly as outlined for cassava.

The Nipa Palm (Nipa Fruticans).

The nipa palm is found growing wild throughout parts of the Malayan Archipeligo, Borneo, the Philippine Islands, New Guinea and Papua.

Description.—The nipa palm is an erect, stemless palm, the leaves and inflorescences arising from a branched rootstock, the leaves being pinnate, 20 feet and more in length. The inflorescence is erect, bears numerous sheathing spathes and both male and female flowers, the former lateral, catkin like, the latter terminal in a globose head. The fruit is globose, as large or larger than a man's head and consists of many abovoid, six-angled, one-celled, one-seeded carpels.

Habitat and Available Areas.—This palm grows only along the mouths of tidal rivers in low, wet land subject to overflows of brackish water as the tide rises each day. It will not thrive in localities where either fresh or sea water alone is available. Extensive areas of nipa palm are to be found at the mouth of the Fly River and in the Delta Division of Papua and smaller areas exist on New Britain and parts of the mainland of New Guinea, particularly at the mouth of the Ramu River. Apart from these areas of nipa, there are other areas of swamp on the mainland of New Guinea which are considered suitable for the cultivation of the palm.

The nipa palm reproduces from seed and also by the branching of its roots. In an artificially made nipa plantation, the seedlings, after removal from the nursery, are planted in drains, 3 feet wide by 1 foot deep. The seedlings are actually placed in recesses cut in the side of the drain so that, when the plant grows, it will not interfere with the flow of water along these planting drains from the main stream.

The usual planting practice is about 200 seedlings to the acre. The plants begin to bear in about four years. It has been estimated by Dennett (1927) that the maximum total cost of bringing nipa into bearing at three years is about $60 per acre (£7).

Alcohol is manufactured from the sap of the palm. The sap as it flows from the stalk is clear and transparent, almost colourless, and very sweet to the taste. In the Philippines (Gibbs, 1911) samples from six different palms were analysed. The results showed that sap of the best quality, as it flows from the flow stalk, has approximately the following composition, stated in grams per 100 cubic centimetres.

Density $\frac{15^\circ}{15^\circ}$	1.0720
Total solids	18.00
Sucrose	17.00
Ash	.48
Reducing sugars	trace

In the Philippines, the best managed nipa groves, or "nipales", are divided into sections about 1 hectare (2.47 acres) in area. Each area contains about 2,000 plants, 700 or 800 of which are producing plants. Estimations of the yield of sap vary within very wide limits. Gibbs (*loc. cit.*), who has made an exhaustive study of the subject, writes—

> "As a result of the experimental work performed by myself and others associated with me in this work, I believe that the average conditions in a 'nipale' cared for according to present methods will result in a yield of 43 litres for each plant during the season, an average daily yield during the period of production of .58 litre and a total yield of 87,000 litres per hectare per year"—that is, 9,300 gallons per acre per year.

According to Gibbs (*loc. cit.*), the production of alcohol from nipa palm sap should be above 6 per cent. of the sap and under favorable conditions it would be 7 per cent. Taking 7 per cent. as the alcohol content of the sap, it is seen that 9,300 gallons of sap would produce about 650 gallons of alcohol, which would be the annual yield per acre.

In Malaya, Dennett (*loc. cit.*) gives the maximum true yield per spathe as .1025 gallons. On a basis of two spathes in tapping per palm, 200 palms per acre and 340 tapping days per annum, this gives a yield of 13,940 gallons of sap per acre per annum. He gives the mean alcohol content as 10 per cent. by volume, so that the mean yield per acre per annum would be 1,394 gallons. He also gives the minimum true mean yield as 1,270 gallons. In "*An Outline of Malayan Agriculture*", *Grist* (1936) gives the theoretical yield of absolute alcohol as over 1,100 gallons per acre per annum, which indicates an actual yield of nearly 900 gallons per acre per annum. Grist's figures are the more recent and probably the more reliable for present-day conditions in Malaya.

The difference between the yields in the Philippines and in Malaya is probably due to the fact that in one country the tapping is seasonal whilst in the other it is continuous. Apparently the farther nipa palms are grown from the equator, the more seasonal is their fruiting period. No observations appear to have been made on the length of the tapping season in New Guinea, but as the territory lies approximately 0° to 8° south of the equator, it is probably continuous. Nevertheless, the lower of the three above estimates, namely, 650 gallons, will be taken as a conservative figure for the yield of alcohol per acre per annum.

An area of wild nipa would contain many more than 2,000 palms per hectare, probably 5,000 or more, but the number of producing palms would be low. By thinning out and dividing the palms into convenient areas by means of waterways, the total number of palms would be decreased to perhaps less than half, but there wound be an enormous increase in the yield per unit area.

Alcohol Production.—The method of producing alcohol from the nipa palm is much simpler than that for the production of alcohol from either cassava or the sago palm. There are only two principal steps in the process: (1) Fermentation of the sap; (2) distillation of the dilute alcohol thus formed. The procedure is briefly as set out below.

Tapping the Palm.—Since the nipa palm sends its inflorescence up from the base, the flower stalk is near the ground and conveniently situated for the gathering of sap. Four years after planting the seed, the nipa bears small fruits, but it is not generally tapped until the fifth year. Some time after the fruit has formed, the stalk should undergo a preliminary treatment known in Malaya as "gonchanging". This process is started when the fruit-head is fairly well grown, but before any darkening of the seed takes place. It consists of gently oscillating the fruit once a day. As the fruit-head grows, the violence of the operation is increased until it becomes a good hard kick or violent shaking by hand. Experience has shown three weeks to be a suitable length of time for this operation, any increase in the period tending to increase labour costs uneconomically. The stalk is then cut across near its top, usually just below the fruit, and each day a thin slice is removed to keep the wound fresh and to facilitate exudation. When a plant bears two flower stalks, the usual practice is to draw sap from only one, the other being removed and the stem allowed to dry up.

The sap is collected in bamboo joints, about 18 inches high and 3 inches in diameter, having a capacity of about half a gallon.

One stalk normally flows for about three months, but it is not uncommon for it to be entirely cut away, at least so close to the ground that it can no longer be utilized by the daily paring of small slices to keep the wound fresh, long before the flow has ceased. In some plantations, the flower is cut before the fruit is formed and under such circumstances the daily yield of sap is said to be increased, but the period of flow reduced from three to one and one-half months, the total yield being practically the same in both cases. The plant seemingly is not affected by this treatment. Where the tapping is seasonal, only a portion of the palms is cut at the beginning of the season in order to supply the distilleries with sap throughout the year and thus avoid shutting down the plant. As these palms are exhausted, the others are brought into production by cutting, and thus the season becomes continuous. No accurate estimates of the length of the time during which the nipa palm will continue to fructify and give sap are available, but all observers unite in saying that this process will continue for many years, perhaps for 50 or more.

Fermentation.—The inversion of the sucrose and the alcoholic, acetic and other fermentations begin almost immediately the sap drops from the stem into the bamboo joints ordinarily employed for collecting the sap, although, when the sap is collected in clean vessels, it undergoes little change for four or five hours. Often the inversion is complete and the alcoholic fermentation well under way, sometimes completed, when the sap arrives at the distillery. On arrival, it is milky in appearance and covered by a thick layer of foam. First, the sap is transferred to large fermenting tanks, some of which hold as much as 3,000 gallons. The fermentation is usually allowed to proceed for 24 hours and sometimes longer. When it has proceeded sufficiently, it is arrested by the addition of lime or some such substance. The liquid is then ready to be pumped into the stills. The simplicity of this procedure gives to nipa sap a considerable advantage over other raw materials which generally have to be prepared for fermentation at the distillery.

Distillation.—This part of the process is practically the same as for cassava and the sago palm.

Raw Material Required for the Production of Power Alcohol.

In Table VIII. are given the quantities of raw materials and the acreage required for the operation of alcohol plants of various sizes for a year of 300 days—

TABLE VIII.—RAW MATERIAL REQUIRED FOR UNITS OF VARIOUS SIZES.

Material.	Unit.	Requirements for the Daily Alcohol Production of—					
		1,000 gallons.			2,500 gallons.		
		Daily.	Annually.	Annual Acreage.	Daily.	Annually.	Annual Acreage.
Cassava tubers..	Ton	21	6,300	630	53	15,750	1,575
Sago palm ..	Ton	25	7,500	690	63	18,750	1,725
Nipa palm sap ..	Gallon	14,300	4,290,000	460	35,750	10,725,000	1,150

Material.	Unit.	Requirements for the Daily Alcohol Production of—					
		5,000 gallons.			20,000 gallons.		
		Daily.	Annually.	Annual Acreage.	Daily.	Annually.	Annual Acreage.
Cassava tubers..	Ton	105	31,500	3,150	420	126,000	12,600
Sago palm ..	Ton	125	37,500	3,450	500	150,000	13,800
Nipa palm sap ..	Gallon	71,500	21,450,000	2,300	286,000	85,800,000	9,200

Alcohol production should not be started unless raw materials are available to provide for a plant of the minimum size capable of producing alcohol profitably. Such a plant should probably contemplate a production of at least 2,000 gallons daily to be able to maintain the essential technical supervision for efficient operation without increasing unit costs unduly. Minimum amounts of raw materials required annually to operate an alcohol plant of this size for a year of 300 days are shown in Table IX.—

TABLE IX.—RAW MATERIALS REQUIRED TO PRODUCE 2,000 GALLONS OF ALCOHOL DAILY.

Material.	Unit.	Required for Distillery Annually.
Cassava roots	Ton	12,320
Sago palms	Ton	15,000
Nipa palm sap	Gallons	8,570,000

Table X. shows the crop tonnage and crop acreage required to produce a quantity of alcohol equivalent to 20 per cent. of the petrol consumed in Australia and New Guinea.

TABLE X.—REQUIREMENTS TO REPLACE 20 PER CENT. OF AUSTRALIA'S AND NEW GUINEA'S PETROL CONSUMPTION.

Material.	Unit.	Amount of raw material required to make 1,000 gallons of alcohol.	Amount of raw material required to make alcohol equal to 20 per cent. of Australia's and New Guinea's annual consumption.	Acreage required to produce material for 1,000 gallons of alcohol.	Acreage required to produce alcohol equal to 20 per cent. of Australia's and New Guinea's annual consumption.
Cassava roots ..	Ton	21	1,260,000	2.1	126,000
Sago palms	Ton	25	1,500,000	2.3	138,000
Nipa palm sap ..	Gallon	14,300	858,000,000	1.5	90,000

The Plant.

Because of the desirability of producing a very cheap and perhaps an impure product, use of the methods and equipment normally employed for producing pure spirits is advisable only when it entails no extra cost, or is justified for reasons other than the character of the product. The general procedure will probably have to be modelled on the conventional process, while costs are reduced by use of short cuts, revision of plant design, or other appropriate deviations. Since the production cost of alcohol depends on raw material, labour, fuel, capital, and overhead costs, each of these items must be held rigidly to a minimum.

Establishing an alcohol plant would be justified only on an expectancy of at least 20 years' operation in order that amortization may be possible without using too high a yearly depreciation percentage, which would raise the unit cost of the production. Extensive repairs or rebuilding or equipment additions would naturally lengthen the required amortization period. Alcohol plants cannot be constructed for efficient operation on a temporary basis and adequate and continual operation should be assured for a long time.

Plants should be located on solid ground as close as possible to: (1) Adequate supplies of raw materials; (2) Constant and relatively cheap sources of pure water, fuel, power, labour, building materials and process chemicals; (3) Facilities for the disposal of waste; (4) A seaport, navigable stream or other means of transport.

Because of the relatively low price that can be obtained for power alcohol any alcohol-producing plant design should provide for: (1) Units of adequate yet economical size; (2) flexibility of raw materials; (3) economy in handling and processing, and the use of automatic devices where economical; (4) possibility of using other fermentations, perhaps simultaneously; (5) quantity rather than quality of product.

PLANT DESIGN.

Selection of a specific plan, construction materials, and detailed building specifications would have to be governed partly by the geographic location. Frame studding and ordinary galvanized walls, with roofing of galvanized metal carried on open rafters, may be sufficient in many cases. Walls and roofs which may be washed down by steam or water are recommended. All wood interiors should be painted, and ledges where dust may accumulate should be avoided. In general all buildings should have substantial floors of concrete, preferably dustproof and non-absorbent. They should be well sloped to convenient sewer outlets and bordered by a curb or rim, on which the wall plates should be placed. This method makes it easy to keep all floor corners clean and free from sources of contamination. Fermenter houses using open-top fermenters should have ventilation down to floor level.

Wooden fermenting tubs are cheaper than steel tubs, but they are more difficult to sterilize and more liable to leak, and there is some loss of the product by evaporation from the top. Wooden tubs should be located indoors to control contamination or other factors, and they should be covered.

Steel fermenting tanks may be located outdoors if of the closed top design. Beer wells are a convenience when the number of fermenters is limited. They should be of metal or non-absorbent concrete, well sloped, and easily accessible for washing and sterilization.

The installation of convenient hoist-supporting beams over certain portions of apparatus (such as columns) is recommended to facilitate erection and dismantling. Walls and floors for any structure should be ample to sustain all the weight likely to bear thereon. Buildings should preferably be fire-proof and well-ventilated, and boilers or open flames must be kept at a safe distance from, and to windward of, refinery buildings so that alcohol vapours cannot reach the boiler room.

Ample track siding and ground storage space for fuel and raw materials are essential. Double sidings are preferable to a single track. Boiler and plant water supplies and adequate sewer facilities are of the utmost importance.

All pipe lines must be carried in the open for complete inspection, and they must be painted in designated colours. All valves, unions, or other openings must be locked or sealed.

The cost of a plant is dependent on both size and design. The kinds of raw material to be used, the amount and type of feed recovery, the recovery of carbon dioxide gas, &c., have a great influence on the design and total cost. Geographic location is also a factor in cost. No general cost estimates can be made, but certain rough computations are possible, as indicated later.

Cost of the fermenting, refining and miscellaneous equipment used in conventional alcohol processes can be established only indirectly. Each manufacturer of such equipment has his own ideas regarding size, design, weights of metal, types and efficiency of distilling columns and plates, &c. Therefore, refineries are frequently built throughout by one manufacturer although specific items made or controlled by other manufacturers may be included. The general designs are about the same. Since plants are usually designed to fit local conditions or raw material, many of the large suppliers of such equipment maintain complete engineering staffs and sell the complete plants (including foundations, equipment, erection, and complete piping) on a guarantee which includes a specific operating cost. The cost of maintaining such service is, of course, included in the gross cost of the equipment. Smaller concerns are more likely to make units to order, rather than to erect complete plants. The responsibility for successful operation of such then rests largely with the purchaser, who formulates the general specifications. Costs, therefore, vary not only with the required labour and the weights of copper or other metal used, but with the degree of advisory engineering detail furnished.

Costs.

INITIAL COSTS.

As indicated in the preceding section, only approximate figures can be given for initial and production costs. Plant costs are continually changing and the cost of erecting a plant in one locality may be quite different to that in another.

From information recently received from America, the cost of a modern American Built convential-type, alcohol plant having an output capacity of approximately 10,000 gallons a day is approximately £133,000. This price includes buildings, foundations, boiler plant, fermentation equipment, distillation equipment, storage tanks, dry house equipment and water and power equipment. It is stated that plant capacities can be doubled for about 1.4 times the initial cost or halved at about .7 of the initial cost. If nipa palm sap is the only material to be treated, the above costs could be reduced by perhaps 25 per cent. or more.

Besides plant costs, there would be the cost of obtaining suitable land for the production of raw material. In the case of cassava, this land would probably have to be cleared, and in the case of areas of nipa and sago palms, these palms would have to be thinned out. The cost of clearing land under jungle or rain forest in New Guinea is about £5 per acre, the work being done by natives. If machinery were employed, the cost would be reduced considerably although there would be the initial costs of the tractors, &c., to be considered.

The cost of thinning out areas of sago or nipa palm would probably be less than £5 per acre and, in the case of the former, the material thinned out would have a high value as readily available raw material for the production of alcohol. In Borneo (Wood, 1925) the cost of thinning out nipa was $10 per acre, which was the contract price at Semawang.

PRODUCTION COSTS.

It is estimated that the cost of producing cassava tubers (including the cost of the planting material) in New Guinea does not exceed 15s. per ton and if the yield per acre is greater than 10 tons, the cost of production would be lower than this amount. At present, all cultivation is done by hand, but if the initial preparation of the land and the harvesting were done with machines, the cost could probably be reduced by at least half.

It would be advisable to follow the cassava with a leguminous crop, such as velvet beans or cow peas, before planting the next crop of cassava. The beans or peas could be harvested and used as a native food whilst the plant could be ploughed in as a green manure. Unfortunately, no figures are available for production costs and yields of velvet beans or cow peas per acre under conditions existing in this Territory. However, it is considered that the value of the crop as a native food for feeding the labour line would probably more than pay for its cost of production.

Unless certain by-products are used for this purpose, the cost of fertilization at regular periods will further increase the cost of production.

No figures are available for the cost of harvesting the sago palm in this Territory. At present, the harvesting is done in a very leisurely manner by native women, the final product consisting of approximately 60 per cent. starch and 40 per cent. water. In the production of power alcohol, there would probably be no need to separate the starch from the fibrous material and once the outer bark had been moved the remaining portion of the trunk could be easily disintegrated and mashed for fermentation. Hence the harvesting costs would only consist of felling and trimming the palm and transporting it to the factory.

It is estimated that two natives could harvest at least five palms per day or 5 × 250 = 1,250 lb. of starch per day. Native labour costs about 1s. per day per man so that the cost of production of total fermentable matter would be less than 4s. per ton.

As there are no records of the nipa palm having been tapped in this Territory, no figures are available for cost of production. In Borneo, Wood (1925) has estimated that one coolie can tap sufficient palms to yield at least 80 gallons of juice per day. Hence it seems reasonable to conclude that a New Guinea native, once he has learnt the technique and gained a little experience, should be able to collect at least 70 gallons of juice per day—that is 70 gallons may be collected for 1s.

FACTORY COSTS.

Cassava and Sago Palm.—From recent figures published by the United States Department of Agriculture ("Motor Fuels from Farm Products"), the cost of production would be approximately as follows:—

Conversion costs.	Average costs in cents per gallon.
Fuel (production basis of 10,000 gallons/day for 300-day year) ..	1.38
Water and power	.50
Labour	2.50
Interest	.85
Depreciation	.89
Taxes and general overhead	.88
Chemicals and supplies	.50
Raw materials (excluding that from which alcohol is made)—	
Malt	2.40
Anhydrous step	2.00
Denaturing	2.00
Total	13.90 or 8½ pence.

These costs have been computed for the production of alcohol from grain, but they are a good indication of what the costs would be if cassava tubers or the sago palm were the raw material. It should be remembered, however, that labour is much cheaper in New Guinea than in the United States.

Nipa Palm Sap.—Wood (1925) gives in detail estimated costs of production for plants of three different capacities when running for 24 hours per day. These estimates are summarized in the following table:—

	2,000-gallon Plant.		4,000-gallon Plant.		8,000-gallon Plant.	
	Per year.	Per gallon.	Per year.	Per gallon.	Per year.	Per gallon.
	$	$	$	$	$	$
Total collecting costs ..	66,000	.18332	132,000	.18332	264,000	.18332
Total distilling costs ..	31,170	.08655	61,620	.08577	103,320	.07175
Total other costs (depreciation, insurance, royalty, cost of running launch, &c.)	31,800	.08830	57,600	.07997	106,800	.07414
Total producing costs ..	128,970	.3582	251,220	.3491	474,120	.3292
Total capital required ..	$272,000		$537,000		$1,044,000	

$1 equals 2s. 4d. (English).

From this table it is seen that the cost of production decreases as the output increases and, for a factory producing 8,000 gallons per day, is about 9d. per gallon.

GENERAL.

In indicating production costs, no attempt has been made to compute total production costs per gallon. Before this can be done, certain field experiments would have to be conducted in the district in which it is proposed a factory should be established in order to check up on the foregoing costs.

However, the estimates given indicate that the margin of profit will not be great unless all costs are kept rigidly to a minimum.

By-products.

If sago palms and cassava tubers constituted the raw material, the recovery of stock feeds from distillery wastes could be an important part of the power alcohol industry. It is usual to strain the solids from the spent slop and then dry them when they are fit for marketing.

Another by-product that should yield large profits is carbon-dioxide (CO_2). This could be collected from the fermenting vats instead of being allowed to run to waste, and can be compressed and sold for aerating and refrigeration purposes. The cost of the additional plant would not be great but the successful retailing of the product would call for good business organization.

During an ordinary yeast fermentation, a small quantity of oil having a characteristic odour is formed. This oil, which is normally separated from the alcohol in the refining columns, consists of a mixture of higher alcohols and esters, but its composition varies with different fermentation conditions and different raw materials. It is used principally as a solvent for lacquers.

The sale of these by-products will reduce alcohol production considerably but, with the exception of carbon dioxide and fusel oil it may be more profitable to return the by-products to the soil as a fertilizer. Ethyl alcohol has the following chemical formula—C_2H_6O, that is, it is composed of only carbon, hydrogen and oxygen all of which are contained in the air. Hence, if the stock feeds produced as by-products in the manufacture of power alcohol are returned to the soil from which the raw material came, the soil will yield indefinitely and the supply of alcohol would be *absolutely inexhaustible.*

Summary.

The possibility of producing alcohol from cassava tubers, the sago palm, and the nipa palm are discussed. Figures for the possible yields per ton and per acre are given, and these figures are compared with similar figures for crops grown in temperate climates.

Acknowledgments.

I wish to acknowledge with gratitude the constant encouragement and assistance which I have received from the Director of Agriculture during the preparation of this report.

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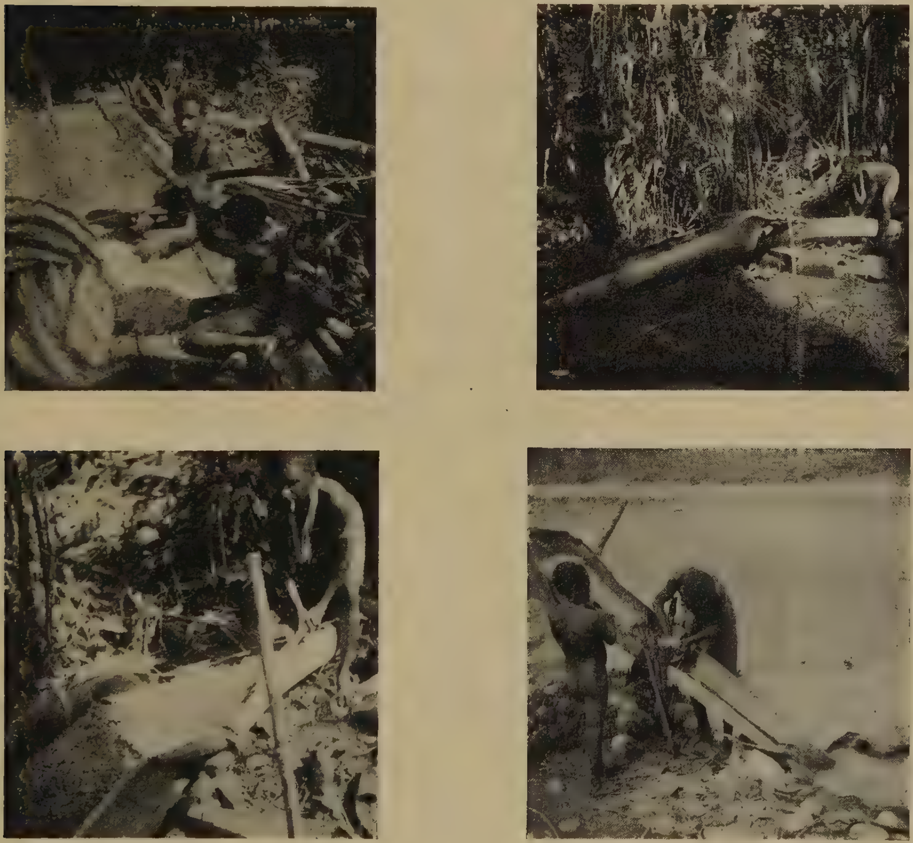

The native method of preparing starch from the sago palm, showing the disintegration of the trunk and the initial and final washings with water.

(Photographs by Wood.)

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EDITORIAL NOTES.

Fertilizers.

IN New Guinea, where cattle are not kept in the same manner as in temperate regions, the lack of farmyard manure is especially felt and the need for substitutes becomes more urgent every year. When used as substitutes for dung, artificial fertilizers have the advantage that they are required only in relatively small quantities because of their high degree of concentration. This is a distinct advantage in New Guinea where transport costs are considerable.

The most important fertilizer constituents are nitrogen, potash and phosphoric acid and, in some parts of New Guinea, iron in the form of iron sulphate.

Nitrogen is a constituent of all vegetable matter, the most important nitrogenous substances in the plant being the proteins and amines. The nitrogen of the air is useless to the plant which is unable to avail itself of this element in the free state, but must find it in a combined form, generally as a nitrate. Even if combined nitrogen be present in the soil in other forms, for example, as organic nitrogen or ammonia, these forms by the action of so-called nitrifying bacteria, are usually first transformed to nitrates, before they are assimilated by the plant. Nitrogen is the element which forces the plant, producing a luxuriant growth of leaves to which it imparts a dark green colour.

Potash plays an essential part in the formation of the carbohydrates of the plant. Plants with a high percentage of sugar and starch, especially cassava and sweet potatoes, respond readily to dressings of a potash fertilizer. Furthermore, as a result of potash manuring, the sugar content of fruits rises considerably.

Phosphoric acid, like nitrogen, is of importance in the formation of proteins of which phosphorus is an essential constituent. It is taken up by the plant only as phosphates in easily soluble form. A good supply of such phosphates is essential for seed and fruit production in all flowering plants and is said to generally hasten ripening.

Although artificial fertilizers have been used in the tropics for years, their use in New Guinea has been very limited. As a result, many old plantations are now declining in yield and some have even been abandoned because of soil impoverishment coupled with other secondary causes.

On an intensively cultivated soil in New Guinea, the quantities of the above constituents removed in a year may reach—

	lb. per acre.
Nitrogen	6
Potash	3
Phosphoric acid	1½

For a single year these quantities may appear small, but over a number of years they are considerable, particularly when it is remembered that nitrogen, potash and phosphoric acid are present in the soil in relatively small quantities.

Many plantation soils have been under European cultivation for half a century or more and before this they had probably been subject to native cultivation. Because of heavy rainfalls and the loose texture of most New Guinea soils, soil impoverishment due to leaching is also considerable although it is difficult to determine, with any degree of accuracy, the extent to which our soils are impoverished by this means. However, the fact that comparatively young plantations are declining in yield because of soil impoverishment is a definite indication that no time should be lost in taking the regular application of fertilizers more seriously.

Fertilizers should be applied each year and although the expense involved in the year during which the work is done may not seem justified immediately, the effects will be more evident as time goes on. Perhaps the most satisfactory way of overcoming the difficulty would be the introduction of legislation enforcing the purchase of so many pounds of fertilizer for each ton of agricultural produce exported. But, no matter what arrangements are made, there should be no delay in putting them into operation.

ERRATUM.

In the May, 1941, issue of the *New Guinea Agricultural Gazette* (Vol. 7, No. 2), reference is made on page 116 to the tung oil tree, *Aleurites fordii*. The correct botanical designation of this tree is *Aleurites moluccana*.

RUBBER PRODUCTION IN NEW GUINEA AND PAPUA.

By R. E. P. Dwyer, B.Sc.Agr.,
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Introduction.

In this survey it is intended to present the various aspects of rubber production in New Guinea and Papua. The survey will be published in several parts, of which this is the first, and will deal with the early development, present position and economic prospects of the industry.

The island of New Guinea is divided into three main divisions—

(1) Dutch New Guinea, in the west, which comprises about half of the total area of the island and consists of an estimated area of 151,789 square miles.

(2) The Territory of New Guinea which is the portion of old German New Guinea once known as Kaiser Wilhelm's Land or North East New Guinea, with an estimated area of 70,000 square miles.

(3) Papua, which was formerly British New Guinea, has an estimated area of 90,540 square miles and is the south-eastern quarter of the island.

Papua was annexed in April, 1883, and became a Territory of the Commonwealth of Australia in November, 1905; thus its period of development has extended over approximately 57 years.

The Mandated Territory of New Guinea has a totally different history. Protected by an Imperial Charter in 1885, the German New Guinea Company laid the foundations for a successful colony which later came under control of the German Government. The first plantation (coco-nuts) was laid out at Ralum at Blanche Bay, New Britain, in 1883, and two years later the first plantation was established at Finschhafen on the mainland.

The Territory of New Guinea was captured and came under Australian military control in September, 1914, and in May, 1921, civil administration was established throughout the Territory. The German Government had paid considerable attention to economic development and the expropriation of German nationals from New Guinea was provided for by the Peace Treaty. The development during the period of German occupation, the military occupation by Australia and the subsequent progress under civil administration has not been collateral with the development in Papua during the same period.

AREA OF BRITISH-CONTROLLED NEW GUINEA.

Mandated Territory of New Guinea.		Papua.	
	Square miles.		Square miles.
New Guinea, Mainland ..	69,700	Papua, Mainland	87,786
New Britain	14,600	Other islands (about 200) ..	2,754
New Ireland	3,340		
Bougainville and Buka Islands..	4,100		
Other islands (almost 600) ..	1,260		
Total Area	93,000	Total Area	90,540

Grand Total, Papua and Mandated Territory of New Guinea—
Area—183,540 square miles.
Dutch New Guinea :—
Area—151,789 square miles.

There are over 600 islands in the Mandated Territory of New Guinea, many of which are quite small. Lavongai, Manus and the Admiralty Islands, Witu or French Island, Kar Kar Island, are some of the most important, other than those already mentioned.

There is a significant difference between the insular distribution of the Mandated Territory and Papua, as only roughly 75 per cent. of the former compared with over 96 per cent. of the total area of the latter is situated on the mainland of New Guinea. That means that almost a quarter, or 25 per cent. of the total area of the Mandated Territory is found on the geological newer islands, compared with less than 4 per cent. of the total area of Papua. There are about 200 islands and islets in Papua but these are mostly small; the main groups are the D'Entrecasteaux Group, the Louisiades Archipelago, the Trobriand Islands and the Conflict Group.

The total area of the Mandated Territory is approximately 24,086,440 hectares or 59,493,507 acres. The proportion of arable land suited for plantation agriculture has not yet been determined. By June, 1938, approximately, 301,000 hectares or only 1.2 per cent. of the total area had been alienated and the percentage of the total area under European cultivation did not exceed .45 per cent. If 2 per cent. only of the total area was available for agricultural development, that would amount to 475,732 hectares or 1,175,058 acres, which is more than four times as much as the area at present under cultivation.

It is a reasonably safe conjecture that the labour available in New Guinea could not develop such an area of plantation agriculture. There is doubt as to whether the present area devoted to plantations could be doubled and the labour found for working it, while gold production continues alongside other development. It is problematical whether it would be possible to develop the area already alienated even after allowing for the proportion of unsuitable land present.

The total area of Papua is approximately 57,945,600 acres. At 30th June, 1939, 1,769,705 acres had been purchased from the natives but actually only 215,489 acres of surveyed land including 23,490 acres of freehold land were held by individuals and companies. In addition to this area, 172,226 acres of Crown land had been surveyed and this includes reserves and areas available for leasing, making a total of 387,715 acres which had been more or less effectively alienated. The purchase of the remaining 1,382,990 acres from the natives, later to be made available for the settlement of planters, oil and gold prospecting, essential reserves for Government purposes, native reserves, &c., is a scheme which could be very effectively applied in the Mandated Territory. This method of making land available and still allowing for native requirements has been in operation for a considerable time in Papua and has progressed considerably as for example, in 1912, 1,023,049 acres (2⅝ per cent. of the Territory) and in 1937, 850,000 acres had been allotted to Crown lands.

The area under plantation cultivation in Papua is a very small percentage of the total area, namely, a little over .1 per cent., which is less than one-quarter as much as the area under cultivation in the Mandated Territory. There is, however, a very striking difference between the distribution of the areas under cultivation in the two Territories.

In Papua, by far the greater proportion of the agriculture is confined to the mainland, whereas, if such islands as Kar Kar (Dampier) Island and other islands are included, about 85 per cent. of the plantation development in the Mandated Territory is on the islands, the greater proportion or about 60 per cent. being on the Bismarck Archipelago. One is not in a position to state the exact percentage of Papuan plantations situated on the mainland but it would seem that possibly more than 85 per cent. of the development had occurred there.

There are several possible reasons for the proportionately greater development of Papuan agriculture on the mainland, but it is mainly because there is not such an area of fertile islands present in Papua. One fact which stands out, however, is that rubber planting, particularly away from the sea coast, has been the main reason why continued development has been possible in Papua.

Only 15 per cent. (approximately) or about 40,000 acres of the total plantations present in the Mandated Territory, are to be found on the mainland. Rubber, high-quality Arabica coffee, tobacco and similar crops will need to be grown to develop the mainland to a much greater extent. In this regard, it must be remembered that the mainland area of North-east New Guinea comprises 18,000 square miles less than the mainland area of Papua and, apparently, carries a denser population whose needs have to be met.

Climatology.

To say that New Guinea and the Netherlands East Indies are located in the tropics is a much too vague classification. Nowhere in Australia are there any areas comparable with the greater part of the Mandated Territory of New Guinea, though there are some limited savannah areas in Papua which are comparable with North Australia.

The expression "the tropics" usually covers the whole broad belt between the tropics of cancer and capricorn—or between 23° south and north latitude. Within this vast belt great differences of climate are found and the strip between 10° north latitude and 10° south latitude within which New Guinea lies (Rabaul is at about 5° south) is quite distinct from the regions flanking it on either side and may be appropriately termed "the tropical zone" in the special sense.

TABLE No. 1(*a*).—ANNUAL RAINFALL AT VARIOUS RUBBER DISTRICTS—PAPUA.

Year.	Abau.	Ioma.	Kemp Welch.	Kerema.	Kikori.	Kokoda.	Magigi (Rona Falls).	Koitakinumu.	Samarai.
1913 ..	106.61*	159.94	54.39*	147.99*	46.75*	110.88*	..	..	92.29
1914 ..	79.02*	112.08*	43.70	70.80*	118.52	102.41*	..	..	62.38
1915 ..	89.33	172.47*	52.16	172.08	245.38	135.22*	..	..	84.49
1916 ..	38.09*	171.63*	73.58	117.83	312.33	158.57	..	..	133.56
1917 ..	47.03*	157.86*	64.10	113.36	238.60	141.23	..	..	179.02
1918 ..	46.16*	154.31	31.53	118.56	173.82	111.80*	..	..	115.73
1919 ..	84.56	159.36	40.03	128.21	223.02	125.76*	..	..	117.21
1920 ..	67.49	72.96*	46.09	115.44*	195.27	97.24*	..	..	36.93*
1921 ..	35.57*	..	31.12*	143.04	270.73	122.20*	..	..	127.81
1922 ..	65.07*	145.91*	45.77*	137.34	222.89	130.88	..	..	125.83
1923 ..	39.85*	88.61*	..	141.59	163.58	110.69*	..	..	99.28
1924 ..	62.75*	145.52	71.39	154.00	239.43	165.50*	..	..	90.48
1925 ..	103.46	121.16	60.42	152.41	209.31	156.49	..	..	89.39

* Incomplete.

TABLE No. 1(*a*).—ANNUAL RAINFALL AT VARIOUS RUBBER DISTRICTS—PAPUA—*continued.*

Year.	Abau.	Ioma.	Kemp Welch.	Kerema.	Kikori.	Kokoda.	Magigi (Rona Falls).	Koitaki-numu.	Samarai.
1926	62.86	143.21	49.61	117.69	266.07	164.23	..	70.48	81.75
1927	82.93	143.37*	64.51	162.83	231.53	150.87*	..	127	109.38
1928	109.36*	165.38	58.68	171.45	217.55	127.27	..	97.77	107.67
1929	65.99*	138.87	64.25	157.21	249.77	134.81	77.68	91.53	96.13
1930	86.36*	75.16*	52.95	175.50	240.00	143.62	57.09	117.03	92.94
1931	68.93*	169.65*	50.98	103.22	227.66	144.90	45.09*	88.38	59.28
1932	79.80*	158.52	56.33	136.76	217.03	110.74*	76.08	94.20	70.33
1933	89.81	198.90*	73.46	146.02	265.51	139.20*	113.37	..	88.23
1934	110.02	182.77	91.03	153.25	251.56	139.20*	88.16	171.62†	141.21
1935	86.24	158.38	42.41	140.85	241.89	86.45*	71.93	129.90	100.30
1936	94.18	169.43	73.61	129.67	280.84	..	92.08	128.80	139.64
1937	108.62	166.89	47.56	187.49	247.49	128.03*	75.67	114.72	114.37
1938	92.82	150.49	59.44	152.32	219.07	131.48	83.77	..	120.54
1939	112.67*	120.61	52.21	157.66	288.68	121.06	81.87*	..	..
1940	..	..	..	..	..	..	..	..	..

* Incomplete.
† Record 40 inches above average for previous ten years.

TABLE No. 1 (*b*).—PAPUA: AVERAGE MONTHLY RAINFALL RECORDS AT SELECTED STATIONS.

Station.	Number of Years.	January.	February.	March.	April.	May.	June.
Abau	10	6.47	6.53	8.72	9.31	10.33	9.27
Buna Bay	24	13.43	12.61	13.14	11.73	9.23	7.71
Ioma	17	17.27	15.25	15.40	11.96	10.72	9.57
Kemp Welch	24	8.07	6.50	8.36	8.54	4.07	2.42
Kerema	23	9.44	8.09	10.68	11.26	16.92	16.33
Kikori	24	11.49	12.57	15.25	17.47	30.23	30.51
Kokoda	10	12.95	12.05	16.02	13.64	12.93	7.61
Orangerie Bay	25	8.32	8.49	9.93	7.95	8.43	7.92
Rigo	21	6.67	4.54	7.73	5.61	2.42	2.29
Port Moresby*	38	6.99	7.57	6.64	4.22	2.50	1.26
Samarai	29	6.92	7.33	10.04	9.76	12.01	11.35

* Savannah Zone—not suited to rubber.

Station.	July.	August.	September.	October.	November.	December.	Yearly.
Abau	10.04	8.10	5.71	4.46	4.93	5.72	89.59
Buna Bay	5.47	4.41	5.72	9.12	13.44	14.60	120.61
Ioma	6.82	9.20	10.69	11.95	18.50	18.43	155.76
Kemp Welch	1.53	1.51	2.18	2.97	4.77	6.83	57.75
Kerema	13.12	13.93	12.47	12.32	9.27	7.35	141.18
Kikori	25.46	21.31	23.90	17.34	13.94	11.79	231.26
Kokoda	6.53	9.50	10.56	11.31	14.41	14.99	142.50
Orangerie Bay	8.43	8.28	6.00	5.04	3.98	5.74	88.51
Rigo	1.44	1.53	1.44	1.71	2.93	4.00	42.31
Port Moresby*	1.10	0.66	1.04	1.38	1.91	4.42	39.69
Samarai	8.08	8.61	10.13	8.71	8.40	5.37	106.71

Kanosia, another rubber area, showed an average yearly rainfall of 60 inches over eight years. Sogeri (Central) for six years, showed an average yearly rainfall of 108 inches.

The first thing to realize is that in New Guinea the seasons do not vary in the same way as they do in Australia or Europe. Summer and winter are not experienced and the days and nights all over New Guinea are each about twelve hours long all the year round. The sun here ascends and descends almost vertically and the periods of dawn and dusk are always short. In New Guinea the thermometer rarely goes over 90° F. and at 100° F. it is a hot day. One feels distinctly cold when the temperature, as it rarely does, descends to 60° F., at low levels. The daily temperature variation is generally so slight that even at a depth of one metre the soil shows no variation in temperature at all.

In Europe a constant soil temperature could only be expected at about ten times this depth.

Seasonal Behaviour of Plants.—The astounding fact that one cannot explain by any of the known theories of photo-periodism or growth theories is that such trees as *Eugenias*, rubber (*Hevea brasiliensis*), *Sideroxylon* and many other types behave seasonally, lose their leaves entirely within a few days in some cases. Flowering and growth, in such species, is most rapid and one has noticed many feet of growth to take place almost within one week. This feature is much more pronounced than with any deciduous trees in Australia.

Papua and New Guinea are situated well within the monsoonal belt and experience north-west and south-east seasons respectively, but they are outside the hurricane zone.

There is an excellent publication on rainfall observations and the climatology of Papua and the Mandated Territory of New Guinea, published by the Commonwealth Bureau of Meteorology in 1940.(1) In this, Hogan gives a brief survey of the weather of Papua and Challis of the New Guinea climate. It is difficult to give an account of the seasonal distribution of rainfall on account of the great variability in type and amount, respectively. This is well illustrated by reference to Tables Nos. 1 and 2 and comparing, say, Kikori with an average rainfall of 231.26 inches per annum, falling on 263 rainy days with stations like Kemp Welch with a 57.75 inches average annual rainfall on 112 rainy days, or Port Moresby, 39.69 inches average annual rainfall on 105 rainy days. It will be seen that there is generally a good rainfall on the coast of Papua and that the rubber districts are mainly found in areas of heavy rainfall, although the actual amount varies greatly according to station. The Kemp Welch Government Plantation does suffer from occasional drought and this is one of the lowest rainfall areas tabulated, with the exception of Port Moresby.

Kokoda is an example of an inland station at the base of Mount Victoria which receives 130 inches per year with a maximum precipitation in the north-west season mainly due to heavy thunderstorms' rains. Port Moresby registers the minimum rainfall for all recording stations in Papua, apparently on account of its being situated well away from the mountains on a small peninsula where the prevailing winds precipitate rarely.

The physical features of New Guinea being so varied account for the diverse annual rainfall averages. It is recognized that the coastal indentations, direction and height of the mountains, &c., deflect the rain-carrying winds, so that in some islands the wet season is experienced with the north-west winds blowing on one side of the island, whereas the south-east season is the wet season on the other side of the island which often is only a relatively short distance away.

TABLE No. 2.—YEARLY RAINFALL AND AVERAGES.

TERRITORY OF NEW GUINEA.

Locality.	1928.	1929.	1930.	1931.	1932.	1933.	1934.	1935.
Sepik District—								
Aitape	*100.54*	120.80	99.82	98.54	97.17	122.94	102.30	*86.97*
Madang District—								
Madang	148.16	141.06	141.36	113.57	117.79	148.44	101.14	153.28
Morobe—								
Salamaua	..	..	..	..	..	..	..	..
Lae	216.65	210.95	..	..	..	..	..	..
New Britain—								
Gasmata	234.34	313.76	133.99	246.29	279.98	171.93	189.56	269.56
Keravat	..	..	92.52	95.57	101.87	99.38	110.63	117.96
Kokopo	59.85	127.74	152.15	92.50	66.81	67.66	58.01	76.14
Notre Mal	..	153.74	152.48	158.70	157.74	141.27	132.55	*140.60*
Pondo	170.09	285.24	124.24	*117.25*	193.07	174.65	118.63	159.16
Rabaul	72.50	109.75	89.97	58.01	104.42	83.49	81.18	108.52
Talasea	159.62	233.33	*171.57*	148.53	179.48	176.07	112.88	165.25
New Ireland—								
Kalili	191.26	214.14	178.65	222.10	252.61	132.83	110.80	242.10
Kavieng	*103.26*	191.60	119.03	124.97	108.42	92.68	96.38	99.62
Namatanai	128.85	214.91	192.33	163.55	176.49	154.99	108.85	168.42
Kieta—								
Kieta	146.95	95.75	99.18	124.63	99.97	132.48	117.81	78.74
Rugen	..	..	..	..	94.27	108.99	100.81	95.08
Manus—								
Lorengau	..	168.38	162.56	163.39	187.11	126.65	155.08	122.75

Locality.	1936.	1937.	1938.	1939.	1940.	Years Recorded.	Yearly Average.
Sepik District—							
Aitape	86.85	110.12	90.86	123.36	104.11	20	99.65
Madang District—							
Madang	154.02	119.16	162.65	..	135.83	24	136.97
Morobe—							
Salamaua	..	187.55	157.80	147.24	159.52	4	163.03
Lae	..	..	163.09	163.30	173.96	5	185.59
New Britain—							
Gasmata	*220.33*	267.73	172.98	191.22	224.33	21	238.10
Keravat	125.72	103.29	76.25	124.64	103.28	11	105.56
Kokopo	84.37	65.41	56.55	86.90	69.87	14	80.51
Notre Mal	168.02	158.07	159.85	136.66	167.25	121	161.62
Pondo	191.86	199.93	141.81	147.39	160.44	15	170.64
Rabaul	109.79	98.90	72.52	82.07	77.57	27	87.31
Talasea	154.46	200.40	152.65	138.48	125.84	21	166.81
New Ireland—							
Kalili	186.72	227.18	123.17	189.12	*126.57*	17	185.91
Kavieng	162.22	116.04	119.47	155.73	103.28	24	121.10
Namatanai	142.59	143.43	143.23	144.44	135.57	23	141.76
Kieta—							
Kieta	93.08	95.72	98.45	101.50	109.63	24	116.74
Rugen	113.34	..	..	..	..	5	102.47
Manus—							
Lorengau	160.94	143.19	129.21	184.43	..	22	152.80

Records in italics are incomplete.

The south-east trade winds prevail throughout the Territories roughly from May to November. These winds continue with marked regularity until about October or November, when the north-west monsoon begins to assert itself in the upper layers. The change in seasons usually covers a period of about six weeks in April–May and November–December, respectively. The north-west monsoon commencing about December is of a more intermittent character than the south-east trade wind and blows with more sudden squalls, generally bringing more rain, except in the more exposed islands where the rainfall is more regular throughout the year.

Both the seasonal winds carry moisture, but the degree of precipitation which occurs is regulated by the altitude and situation of the land areas which they strike *en route*.

In addition to the mainland ranges mentioned, high mountain ranges are found in the outlying larger islands of the Mandated Territory. In New Britain, New Ireland and Bougainville Island there are central backbones of mountains forming a distinct divide. On the western side of these barriers, the north-west season is the wet period while on the eastern side the dry season prevails. The exact opposite occurs in the south-east season.

Reference to Table 2 will show that there are no low rainfall belts in the Mandated Territory comparable with that at Port Moresby, the nearest approach being at Bulolo and Marienberg. The annual rainfall averages range from 55 inches at Bulolo in the Morobe District to as high as 277 inches at Ring Ring, on the south coast of New Britain. The rainfall on the coastal areas of this Territory are generally comparable with those in Papua. The greater proportion of the Territory is within the 100-in. to 200-in. isohyet and one large area on the south coast of New Britain comes within the 200-in. to 250-in. isohyet, and this is probably the wettest area in either Territory. It might be pointed out, however, that the largest area within the 200-in. isohyet is around the Delta Zone in Papua. There is generally a heavier distribution of rainfall in New Guinea than in Papua.

Topography, Geology and Soils: New Guinea.

The mainland of New Guinea is very mountainous; the central range rising to about 14,000 feet in Papua, and, approximately, 15,000 feet at Mount Wilson in the Bismarck Range of the Mandated Territory. The highest mountain is Mount Queen Wilhelmina in Dutch New Guinea, which is over 17,000 feet high and extends practically to the snow-line.

The average distance between the shore and the mountains ranges from about 10 to 60 miles, if the banks of rivers and deltaic areas are excepted, although in some places the country is mountainous right to the sea-coast.

The outlying islands are very varied in structure, the coral islands are usually flat and devoid of topographical features, but most of the larger islands are mountainous in the centres.

New Britain, New Ireland and Bougainville Island each have a central backbone of mountains. In New Britain there are several high peaks, the highest being Mount Ulawun (The Father, 7,546 feet) and Mount Bamus. In New Ireland, some peaks rise to almost the same height and near Kieta, Bougainville Island, is Mount Balbi (10,172 feet).

The New Guinea mainland, which was apparently attached to the Australian continent at one stage, is now only separated from it by the narrow Torres Strait.

The main central ranges of New Guinea run almost at right angles to the Great Australian Divide and the whole island is situated on the great submarine shelf which links up many of the South Sea Islands.

The geological and ecological conditions are much the same on the mainland of New Guinea, whether it be in the Dutch New Guinea, Papua or the Mandated Territory side. It would appear, however, from reconnaissance surveys that larger areas of older rocks are more generally exposed in Dutch New Guinea than on the British end of the island. Geological investigations have shown that very old rocks exist in Central New Guinea and Papua (of probably pre-Cambrian age).

Through the courtesy of Dr. Whyte, the author when visiting Java in 1934 saw 25 soil types, collected from Dutch New Guinea. Some of these were very old, reddish and very laterized soils, derived from granites, andesites, shales and sandstone formations. There are old Jurassic and the more recent Tertiary formations present.

It seems that volcanic action had almost finished in the Tertiary period in Dutch New Guinea as was the case in Australia where the main basalt formations also belong to this period. The alluvium derived from andesites (especially) and granites represent quite good soils which occur in patches up to 30,000 acres in extent. In the higher regions of the Dutch Territory there are large limestone massifs which yield reddish residual soils; in some areas sandy quartzite soils are said to exist.

In the Bismarck Archipelago and Bougainville Island, the oldest foundation rocks are mostly of secondary origin though in the Bainings Mountains and central ranges some older rocks appear. A great proportion of the formations in these islands which are apparent at the surface are recent to very recent in age, especially where volcanic action has continued right to the present time.

It should be noted that the oldest exposed rocks in Java are of old Tertiary and Quaternary formations which are geologically recent compared with older formations mentioned from New Guinea. Very recent volcanic soils are plentiful in Java and this fact largely accounts for the fertility of the soils and development of agriculture there.

Malaya, on the other hand, has large areas suited to rubber-growing because of the widespread and long-continued erosion from the hills and the extensive alluvial deposition on to the lower areas which has taken place in geologic time.

The stratification of the chief geological formations found in Papua and their sequence was listed as early as 1905.(2) Among the more recent rocks are grits, sandstones and conglomerates of Quaternary age. Greenish sandy shales, limestones and silicious beds of Tertiary age are present, e.g., the Port Moresby beds. Greyish, blue and green limestone of Cretaceous age are found, such as the Boioro limestone and the Purari River beds.

The Strickland River indurated calcareous shales are said to be of Jurassic origin, and these rest on old limestones of Devonian age. Earlier formations are crystalline schists and other metamorphic rocks. Limestones are developed to a very great extent in the Papuan deposits and are present as large barrier cliffs at the edges of the Central Plateau.

In some areas these limestones rest on schists (metamorphized) and in other areas on igneous rocks.

Recent volcanic activity and younger soil formations are much more widespread in the larger islands of the Mandated Territory than anywhere in Papua where such areas are of relatively limited extent. In some of the islands of the Mandated Territory, limited volcanic activity has continued right down to the present time and, in these areas, the richest soils are found. Generally speaking, the most fertile soils in this Territory are in proximity to active or semi-active volcanoes, e.g., on the Witu or French Islands, Talasea, District of New Britain, Kar Kar or Dampier Island, Bougainville Island and the Gazelle Peninsula of New Britain, a large area of which was covered by the eruption of May, 1937.

In Papua, probably the only areas showing any comparatively recent volcanic activity are in some of the smaller islets, e.g., Goodenough Island.

In both Territories there are deltaic and estuarine deposits at the mouths of the main rivers and streams where mostly good agricultural country is to be found except in the swampy areas.

In Papua, several of their rubber plantations are situated on formations of this type, while similar areas were also selected for rubber by the German settlers in New Guinea.

There are large areas of coral islands and also raised coral rocks fringing the larger islands and Mainland of New Guinea. It is on the soils of these such areas that many coco-nut plantations are situated.

There are several reasons for stressing the relative ages of the rocks and the derived soils in these Territories. As a general rule in the tropics the fertility of the soils is inversely proportioned to the age. The loss of fertility with age is much greater and speedier than in the temperate zones, owing to the heavier rainfall and the excessive leaching of soluble chemical nutrients which occurs. This is to some extent alleviated where alluviation is on a large scale.

The importance of repeated volcanic activity in keeping up the fertility of such tropical countries as Java cannot be over-estimated. In the Mandated Territory by far the greater proportion of the plantation agriculture is found on the islands where the soils are geologically newer, though this is not the case in Papua.

Stanley⁽³⁾ and several other geologists have dealt at length with the geology and other features of the Mandated Territory.

The former remarks that—

> Some of the rocks in the Territory decompose into rich, loamy soils, suitable for the growth of coco-nuts, cacao and rubber, &c., and it is important before taking up land for agricultural purposes to have the area tested. A soil survey will give the planter an idea of the type of crop to plant and indicate the possibilities of a particular area. Its importance becomes apparent when it is realized that soils vary considerably in any one district depending almost entirely upon the rocks from which they have been formed.
>
> The rainfall and soil conditions in the Mandated Territory are ideal for the growth of rubber. It is unfortunate, however, that some of the rubber plantations here were raised near the coast line. Although the soil is so suitable, the rubber trees seldom do well when exposed to sea breezes. The ideal situation for the cultivation of rubber appears to be sheltered valleys away from oceanic influences in a soil rich in volcanic sediments and a little limestone.

A large proportion of the soils fringing the Mainland and the larger islands are of coral derivation as previously stated, and have often been raised by volcanic activity in the centre or tectonic earth movements. The coralitic soils usually merge into soils derived from volcanic rocks or from older geological formations, where the landward portions of the plantations run into the hilly country.

The soils next in importance are those derived from volcanic sand, pumice, tuffs, &c., all of which are very porous, and to a lesser extent from lava flows as at Talasea and Kar Kar Island. A few of the existing coco-nut plantations and portions of a large number of them, some with rubber also planted, are on soils derived from other rocks, plutonic, metamorphic or sedimentary (e.g. syenite porphrys in Kieta, trachytic andesites, Gazelle Peninsula and porphyrites and salicified sedimentary rocks on the Bainings District of New Britain). Finally, there are the plantations situated on the estuarine deposits of the Mainland, already referred to and which, like the coral areas, are usually flat. Thus on the Mainland near the coast and on the courses of the three principal rivers, Sepik, Markham and Ramu, is more or less level country, but this only forms a relatively small fraction of the total area.

The question of transport by sea, lack of roads, the general ruggedness of the country, and the fact that many of the central areas are only under partial control has mainly confined the selection of plantation sites in both Territories to the sea coast and mostly to the best anchorages.

Almost the whole surface of New Guinea below the timber line is covered with an apparently impenetrable tangle of forest trees (rain-forest) and undergrowth matted and meshed with tropical vines. Usually in the virgin forest the undergrowth is not so dense as would be first thought.

There have been numerous references to the inland plateau near Mount Hagen and at the head of the Ramu River. This area has great prospects for other crops, but generally the altitude is too high for rubber culture.

General Economy.

The Territories of Papua and New Guinea are very similar in natural resources, population, physical characteristics and geographical conditions, &c.

The natives in general are of a similar type, although of course many different tribes and standards of intelligence are represented in the natives of both Territories.

There are quantitative differences as to population, labour, cultivated land, also deviations in economic development and policy. It is certain, however, that the general conditions in Papua more closely parallel those in the adjoining Mandated Territory than those of any other tropical country. It is for such reasons that the progress of the rubber industry there is of such particular interest to the survey in progress and is dealt with as fully as possible.

In Papua, the author has had only personal experience of the plantations around Sogeri on the Astrolabe Tablelands which is perhaps the biggest rubber district, and also with the general conditions at Samarai and Port Moresby.

The present Director of Agriculture and other officers in the New Guinea Department of Agriculture have had close contact with rubber planting in Papua, especially in the early stages of development, and the results of their experiences have been made use of. Reference has also been made to various articles and reports giving particulars of the rubber planting industry there.

Development of the Rubber Industry in Papua.

The first rubber exports from Papua from 1885 until about 1908 were derived from the indigenous tree *Ficus rigo*, and from indigenous rubber vines, which are discussed later.

INTRODUCTION OF PARA RUBBER.

Messrs. Green and Garrioch introduced the first Para rubber plants into Papua.(4) On the 24th December, 1903, they planted 8 acres of *Hevea* rubber at Sogeri and the following year 5 acres. The Government also imported 100,000 seeds in October, 1906, but it was not until about three or four years later that a determined start was made with rubber planting. The derivation of these rubber seeds is not stated, but it is believed that they came from Malaya, to where they were introduced via Ceylon. In any case, they were derived from the same original stock as all other *Hevea brasiliensis* planted in the East and would be just as variable in the unselected state, containing the same percentage of high-yielding trees.

In 1907, according to Staniforth Smith,(5) there were ten Government nurseries in existence containing about 230,000 young *Hevea* rubber trees available for planters, at different places between the extreme west and the extreme east of the Territory.

ESTABLISHMENT OF GOVERNMENT PLANTATIONS.

The policy of creating Government plantations was inaugurated by Sir William Macgregor from 1895 to 1898, when small areas were planted with coco-nuts at Rigo and Daugo Island in the Central Division, and at Samarai and Gasila Islands in the Eastern Division. Owing to the limited revenue available, little further progress was made until about 1910 when the Federal Government decided to grant the Territory of Papua a loan of £5,000 a year for five years for the purpose of developing Government plantations.

Three plantations were originally started with this grant: one adjoining the Government Experimental Station on the Kemp Welch River in the Central Division, where 277 acres of rubber were planted; the second at Orangerie Bay (1,000 acres of coco-nuts) and the third at Nare Island. The two latter plantations were situated in the Eastern Division and were intended for coco-nut plantations.

In addition to the above, small Government plantations or experimental stations of about 20 acres were established in the various districts, the main ones being at Milne Bay (sea level) and Hombron Bluff (1,800 feet).

The Hombron Bluff Experimental Station was started in a situation about 20 miles from Port Moresby, at an elevation of about 1,800 feet, and various types of rubber were amongst the plants tried out.

The original grant by the Commonwealth Government to the Territory for establishing the above-mentioned plantations was £5,000 per year for five years without interest. This amount was subsequently increased to a total of £27,500 and to this fund an additional £2,500 was contributed from Papuan revenue, bringing the total expenditure to £30,000.

In the 1927–28 Papuan Annual Report, it was indicated that the success of the Government plantations at Orangerie Bay and on the Kemp Welch River enabled the Papuan Government to pay off the Commonwealth loan in full. The last instalment was paid from the earnings of 1927–28 and the total repayments were made entirely out of plantation profits.

A small Government rubber station is established at Kokoda and, although it was apparently established in 1907, little mention of it is made in the annual reports. Clune[6] refers to this station, which has done very good work in proving the prospects for rubber in that district. The latest figures show that 8,886 trees yielded 88,584 lb. of dry rubber in the year ended 30th June, 1939. This averages practically 10 lb. per tree, equivalent to a return of £50 per acre with rubber at 1s. per lb.

The establishment of these Government rubber plantations was a very sound scheme, but in the light of present knowledge there are some weaknesses in the project as conducted now. It seems that formerly the plantation was mainly run commercially with the object of arriving at the suitability of the district, the costs of production and probable returns from the crop. It would also seem that the plantation was inconveniently placed, and the unit area was rather small to arrive at the lower costs of production possible. It does serve, however, to show what a small planter can do, under the particular conditions existent in Papua. In the past there has been apparently only a small amount of provision for experimentation and very little with the object of developing superior high-yielding planting material, which should now be one of the main objectives of such a Government-controlled plantation. Some work is now proceeding along the lines of seed selection, but more than this is required.

At the several Government rubber plantations in Java and at Sungei Buloh Plantation attached to the Rubber Research Institute, Malaya, it is found possible to carry out extensive rubber improvement work, and at the same time make the plantations pay.

It is reasonably certain that similar work will be carried on at the newly opened up rubber plantations at Ransiki River, in Dutch New Guinea, where they are starting with the best clones* available. The increased yields which would accrue from rubber trees developed to yield three or four times as much as the normal yields in Papua would quickly pay for the work involved and would be of great value to the country generally.

KEMP WELCH GOVERNMENT RUBBER PLANTATION.

Kemp Welch Plantation is a source of revenue to the Government and no doubt fulfils a most useful purpose. It has apparently been a successful venture and has served as an efficient demonstration of the possibilities of rubber growing in Papua.

The precaution was taken to grub out all stumps and roots before planting which greatly lessened the danger from fungoid root diseases, though it may have proved rather costly. This plantation is comprised of 277 acres, of which 230 acres contained 10,600 tappable trees according to the 1925-26 Annual Report, and 47 acres with about 2,250 younger trees, of which a considerable proportion were approaching the tapping stage. (At the present time these are mature trees.)

In the 1938-39 Report[7] there is reference to a new area of 40 acres which was cleared and ready to plant by December of that year, which brings the total to 317 acres. It was stated that, other than a small increase in the labour force, very little additional expense would be entailed when this new area reached the tappable stage. It is understood that this new area was planted up from selected seed.

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* A "clone" is any number of individual trees derived by vegetative propagation from one original selected mother-tree.

In the 1937-38 Report(8) the manager reported that he had over 1,000 plants in the nursery derived from seed which had been obtained from the Koitaki Rubber Estates. This seed was probably harvested from a selected area of rubber which will be referred to under the heading of seed selection. There were also some 3,500 plants grown from local seeds (it is not stated whether these were from selected trees) in the nurseries, all of which were doing well.

In 1926, there were 30 native tappers employed, each with a task of 350 trees to tap every day, except Sunday. In August and September of that year, the trees were "wintering" and the yield fell off somewhat. The average monthly output of dry rubber was 5,251 lb., which, for the full year, gave a yield of 28 tons 2½ cwt. for the 10,600 trees tapped, or an annual yield of approximately 6 lb. per tree. The plantation showed a net profit of £4,006 13s. 6d., or over 7s. 6d. per tree for that year.

In the 1930-31 Report(9) it was stated that the estimated loss for the year was £1,043 10s., chiefly owing to the very low prices of rubber prevailing, namely, rubber was at 4d. per lb. in 1929-30, and fell to 2⅝d. per lb. at one period.

The position would have been much worse if the Commonwealth Government had not imposed a duty of 4d. per lb. on all rubber except that coming from the Territories.

The yearly average rainfall at Kemp Welch was 63 inches, but in 1930 only 31.96 inches were recorded and this reduced the yield from 19¾ to 14¾ tons.

In 1935-36, the yield was about 447 lb. of dry rubber per acre, and in 1936-37, 63,626 lb. was harvested, or approximately 454 lb. per acre, while in 1937-38, the yield increased to 64,334 lb., or almost 460 lb. per acre. The actual net profit for this latter year amounted to £898, which was the lowest figure since the year 1933-34, and the drop was attributed to the fall in the price of rubber. Another factor in the drop in profit was because of the 2d. per lb. assistance which was received for the four years preceding 1937-38 not being paid.

According to the manager, another record was established in production figures for the estate, some 66,653 lb. dry weight of rubber sheet being produced in the plantation, 88 per cent. of which was of the highest grade. The manager was of the opinion that this figure will be exceeded in 1940 without over-tapping.

The plantation produced a net profit for the year of £866, despite the fact that over £273 was paid to a relieving manager.

Costs of production on this plantation will be dealt with under that heading.

In 1936-37, it was found that many of the trees were suffering from "die-back" associated with the rather weakly parasitic *Diplodia* fungus. The conditions associated with this disease at Kemp Welch are not accurately known. The most typical form of "die-back" is found, however, on steeply sloping hilly areas which have suffered badly from erosion or on areas which have been neglected in some way. Rubber trees growing for some years also tend to exhaust the soil and this may lead to reduced vigour and consequent "die-back". The reduction of leaf canopy due to any cause leaves the branches open to sun scald and heating of bared branches, with later infection by the "die-back" fungus.

In the Papuan Annual Report, 1937-38,(10) it was stated that "the plantation again looked well," and that "the 'die-back' disease is practically under control," while the manager was hopeful that he would eradicate the whole lot of it by the following year. Judging by the annual yield increases, this condition had not been so serious as was formerly thought, and the returns from new planting are probably more than balancing the loss in production from affected areas.

NATIVE RUBBER PLANTATIONS: PAPUA.

According to Annual Reports of Papua,(11) particularly those of 1920-21 and 1927-28, there were sporadic attempts to develop planting of rubber by natives in Papua. In 1920, it was recorded by the Assistant Resident Magistrate of the Kokoda District that 7,169 rubber trees were planted in 27 villages at the same time as 4,523 coco-nut palms were planted in 25 villages, which, in 1921, were then over five years old.

The natives were also encouraged to plant lime trees (as they could be taught to tap their rubber trees). The idea was to coagulate their latex with lime juice so they could manufacture and smoke a fair grade of rubber for market. It was also remarked that no native rubber was tapped in 1921-22 owing to low rubber prices.

RUBBER PLANTINGS AT GOVERNMENT STATIONS.

In the 1927-28 Annual Report,(12) the following information is given regarding rubber planting at Kerema Station in the Gulf Division. "The whole of the available land adjoining the station has now been planted with rubber, 4,171 trees in all, or approximately 39½ acres; 850 trees of this area were then being tapped." The present Director of this Department was associated with this work in the first instance.

Two hundred acres of hilly land were purchased about 2 miles from the station on the Cupola-road. This area is gradually being cleared by local natives under contract. Two villages started to work during the year and then gave up. Others have taken their place and carried on and at the close of the year there were three villages working about three blocks of about 100 acres in all, most of which has been felled, while approximately 45 acres in the three blocks were burnt off and garden produce planted. This at the time is being lined up and holes dug for rubber planting.

In the Delta Division, the Station Rubber Plantation had also been established and yielded 6,602 lb. of rubber in 1927, of which 5,730 lb. comprised dry rubber and 872 lb. scrap rubber, exceeding the previous year's figures by 521 lb.

Apparently, these native and station rubber areas have not been continuously tapped; nevertheless, they are still in existence and, according to the Director of Agriculture here, the healthy condition of the trees in the Gulf and Delta Divisions led to larger areas of land being recently alienated there for the extension of planting while rubber is at payable prices.

EXPLOITATION OF NATIVE RUBBER IN PAPUA.

In the early days, e.g., from 1885 to 1912, of the rubber industry, exploitation in this country largely consisted of rubber derived from the indigenous tree *Ficus rigo*. It is believed that only very small quantities of this indigenous rubber have been exported since that time, and only when prices were extremely favorable.

INDIGENOUS TREE-RUBBER, *Ficus Rigo.*

According to Staniforth Smith,(13) the chief rubber-yielding plants indigenous to Papua are *Ficus rigo,* Bailey, and a species of vine the identity of which has not been definitely determined. *Ficus rigo* is a tree which is found chiefly in the Rigo District, where it is known to the natives as " Maki ". It furnishes rubber of good quality, which has been collected by the natives for export. Before the war, small-scale experimental plantations of these trees were planted in Papua. About 1912, specimens of the *Ficus* and vine rubber from Papua were sent to the Imperial Institute for examination.

Sample No. 1.—Indigenous tree-rubber, *F. rigo,* from Central Division.—Irregular lumps of rubber, which were slightly sticky externally in places. The rubber was clean and varied in colour from light to dark brown; it exhibited good elasticity and tenacity.

RESULTS OF ANALYSES.

	Per cent.
Loss on washing (moisture and impurities)	3.6
Composition of dry rubber—	
Caoutchouc	91.1
Resin	4.9
Protein	3.1
Ash	0.9

It was valued at about three-quarters the value of fine hard Para rubber at that time.

The sample was very satisfactory in chemical composition and in physical properties, and, if free from stickiness, the rubber would realize a higher price than was quoted.

Sample No. 2—*Vine Rubber.*—This sample contained a considerable amount of impurity, and was sticky externally. The percentage of caoutchouc in the dry-washed rubber was 86.8 per cent. and the percentage of resins, 11.1 per cent., was rather too high.

Rubber of similar composition but well prepared would not bring much less than the *Ficus* in price. Formerly, it was necessary to have a licence to collect bush rubber in Papua except on owners' holdings, and it is believed that this provision is still in force.

Rubber is one of the approved plants listed by the Government to comply with the planting conditions set out for agricultural leases under the Lands Ordinance.

ESTABLISHMENT OF RUBBER PLANTING BY COMPANIES AND INDIVIDUAL PLANTERS.

It would appear that rubber planting in Papua on a commercial scale commenced in 1906, about the time the British New Guinea Company was formed, but had not made much progress until 1910. This company, which is still in existence, was heavily capitalized when it came into existence with a nominal capital exceeding £1,000,000. It was a trading and shipping concern and had varied planting interests, much the same as the German New Guinea Company had in the Territory of New Guinea and Burns Philp and Steamship Trading Company have in Papua to-day. A great proportion of shareholders were small investors living in England. This company is the largest of the pioneer companies which commenced rubber planting in Papua. A combination of circumstances such as over-capitalization, early mismanagement, and other factors later caused them to sell out some of their interests. Papua must be greatly indebted to the early initiative and continued progress of this company, particularly in rubber and coco-nut planting. Despite many setbacks, especially when prices for their products sank to ruinous levels, they have carried on and for several years under capable management and direction have paid substantial dividends, on a somewhat lower capitalization.

The author has not a complete list of the rubber companies operating in Papua nor particulars of the early development of some of these estates. Of rubber-planting companies which started around 1910, a few have gone into liquidation and others have sold their interests to other concerns. Further, several of the plantations devoted to rubber are also growing coco-nuts and other crops, also some companies and individuals who intended to plant rubber when prices were high in the early boom period were influenced by the low prices prevailing in the years 1921-22 or for other reasons turned their attention to coco-nuts.

The British New Guinea Company has been mentioned, but there were several other enterprising companies and individuals associated with the early development of rubber growing in Papua. As already pointed out, the Government and officials showed initiative in supporting their enterprise at the commencement.

At Sogeri, Koitaki Rubber Plantations Limited is one of the most progressive concerns in Papua, and is under capable management, which has been associated with this large plantation practically since its inception. Much can also be said for the initiative of private planters, such as G. H. Loudon, who has developed a very fine rubber plantation, Eilogo, at Sogeri, and paid for much of the cost of bringing into bearing with good-quality interplanted coffee. This coffee has also proved a useful revenue producer when rubber prices were low.

In a 1916 Report on British and Australian Trade in the South Pacific(14), the evidence of the representatives of two Papuan rubber-planting companies is included. The plantation of the Milne Bay Rubber Proprietary Limited is situated at Milne Bay, about 30 miles from Samarai in Papua. The following particulars were given:—

The total area of the property is 10,000 acres, of which 1,750 acres were cleared by 1916, 1,421 acres being planted to coco-nuts and 135 acres planted to rubber. The planting was commenced with rubber in 1910, and in October, 1916, the trees planted in 1911 were five and a half years old and just arriving at the tapping stage. (These trees would now be 30 years old.) The company commenced at first with rubber planting, but later went in for coco-nuts as indicated. The rubber pests, rats and wild pigs were rather serious and caused a great deal of trouble by destroying the young rubber plants.

Planting was being continued, but the pace of planting slackened as the area increased as the bulk of the labour was engaged in keeping down weeds and in conserving the planted area.

It was also stated that amongst the most obstinate pests was Lalang or Bladey Grass, *Imperata arundinacea*, which costs £2 to £3 per acre to keep down (this pest can now be kept down by proper cover-cropping and management), and the presence of root fungi was also referred to.

As to communications, a government road runs from the sea frontage of Milne Bay through the plantation to the properties beyond, and the seaport Samarai is 30 miles away by launch.

Domara River Plantation(15) is on the south-east coast of Papua, near Abau, half-way between Samarai and Port Moresby, the total area of the lease being 2,500 acres, and in 1916 the planted area was something over 700 acres, consisting of rubber trees and coco-nut palms and in addition to copra driers a rubber factory was built. It was estimated that the cost of bringing the rubber into bearing on this property was £30 to £35 per acre, and that before putting in the rubber trees a cover crop has to be put in to keep down the undergrowth if this estimate is to be realized.

Abau Plantation mentioned above was privately owned and only partially planted with rubber.

There are some individual rubber planters on a small scale in Papua, who also combine coco-nut growing and trading amongst their diversified interests. Their factory equipment and plantation buildings are must less elaborate than those of the larger companies, and still they manage to turn out a high-grade marketable product.

Some other rubber companies which are operating or have grown rubber in Papua are as follows:—

Kuala Selangor, on the Robinson River.

Mullin's Harbour Plantations Limited, on Mullin's Harbour.

Papuan Products Company Limited, a New Zealand company, apparently now partly taken over by another newly formed company.

LATER DEVELOPMENT.

In the *Pacific Islands Monthly*, 23rd March, 1937, there are particulars of some intended extensions of rubber planting in Papua—

> With the object of planting rubber on an extensive scale in the Kanosia District, Mariboi (Papua) Rubber Estates was incorporated under the Papua Companies Ordinance on the 15th February with a nominal capital of £50,000, in shares of £1 each. Steamship Trading Company are interested in the enterprise.
>
> The company, it is understood, will take over a considerable area of land from Tropical Products Proprietary Limited, incorporated in January. The latter recently acquired 9,000 acres at Kanosia for planting rubber and other tropical products.
>
> Kanosia is a well-known and tested rubber district in Papua, within easy reach of the seaboard.

The district mentioned is situated in the Central Division, approximately opposite Yule Island, where a decidedly greater rainfall is experienced than in the dry zone around Port Moresby itself.

Another rubber-growing district which has come to the fore is at "Kokoda", in the Northern Division of Papua, which is on the Mandated Territory side of the Owen Stanley Range and almost adjoining the Morobe District. This area must be on almost the same type of geological formation as exists in the latter district.

There are no roads to this area and the freighting of supplies and prepared rubber is by aeroplane, as these interior mountains have apparently proved impassable for roads. When flying from Port Moresby to Kokoda, the Central Range has to be passed over at 12,000 feet, with Mount Victoria (14,000 feet) lying just to the west. The plantations are situated in the Yodda Valley to Ioma (pronounced "Yoma"). Clune(16) describes a recent visit to Kokoda and Lolorua Plantations in very interesting and popular style, and gives a good idea of the difficulties surmounted in establishing rubber growing in this area.

It seems that in this district there is an abundant supply of labour of the Orakaiva tribe, who are anxious to work. Lolorua Plantation has an area of 1,250 acres, containing 50,000 trees in tapping and another 50,000 trees planted, and the manager said that "the average yield is approximately 7 lb. of dry rubber per tree per year, or 700 lb. per acre.".

The climate and soil conditions are ideally suited to rubber and the elevation of about 1,000 feet is also optimum for rubber as is shown by the girth development and latex yield of the trees.

The "Sacred Heart Mission" intends to plant rubber at Sagarai Valley District in the Eastern Division; other areas are also being cleared in this vicinity and made ready for planting. This area is close to Milne Bay.

At Kikori in the Delta Division, another area suited to rubber-growing is found. The plantations here, situated on the banks of the Kikori River, have an average annual rainfall of over 230 inches.

The Plantation Industry in Papua.

TRANSPORT DIFFICULTIES.

The companies and individual planters who commenced and founded the rubber industry in Papua are to be commended. This was carried out in the face of many difficulties including the teaching of Papuan labour how to tap the rubber trees and carry out factory operations, &c.

The transport facilities were decidedly lacking and this was especially so in the case of those plantations situated in the Sogeri District on the Astrolabe Tableland.

Dr. Klein visited Papua and New Guinea as a member of the Dutch Colonial Institute and in a later report(17) made the following comments:—

> Rubber is doing well in Papua and, although it is the only commodity that private enterprise would at present, like to start on the Dutch side, the international rubber restriction (at that time) prevents us from doing so. Looking at the absence of restriction in Papua, one wonders why they did not increase more quickly and then the lack of a road leading to the best rubber district (Sogeri) seems to me (i.e. Dr. Klein) to explain this.

In the early days when Itikinumu, Koitakinumu and other plantations were established at Sogeri, the machinery, stores, &c., were all brought in by native carriers, the costs were high and there was little chance of replacement if any breakages occurred.

At the present time there are about 3 miles of road on a relatively steep mountain pass scouting the Rona Falls, where mule trains are employed to carry the processed rubber and coffee over the pass and out to a motor road which ends at Rona Falls. On the return journey, the stores are brought back to the plantation (or a depot to be later picked up by motor lorry).

It was only in 1928 that a start was made by the Koitaki Company and the British New Guinea Development Company Limited, with the assistance of a grant of money from the Government to construct a motor road from the latter company's "Itikinumu" estate through "Koitakinumu", to within a distance of 3 miles of Rona Falls. This is the road on the Sogeri side of the Falls, which extends a distance of 7½ miles still leaving the 3 miles of uncompleted road, where the mule trains are used at the present time to link up with the 21 miles of motor road leading to Port Moresby.

It would seem that over the years the money involved in putting in those 3 miles of road would have been returned over and over, or at least the interest on the money, would have been.

In July, 1936, an effort was made by some of the members of the Papuan Legislative Council to induce the Papuan Government to ask for a grant, or loan, from the Commonwealth of up to £15,000 to enable them to complete the road from Rona Falls onward for motor traffic and to erect a high-level bridge over the Laloki River. It seemed that little further was done in the matter until recently when £5,000 was granted for the purpose but there may have been some good reasons for this. It was urged by the planters that the completion of this road would be an inducement to investment in this district, where thousands of acres are said to exist which are ideal for rubber, coffee and possibly tea. If the 3 miles of road were completed, this would do away with the pack-animals as used over the past 28 years to and from the Sogeri District.

Apparently, the Government sent District officials to look over the district where the planters contended that extensive rubber areas existed, and the report was unfavorable. See *Pacific Islands Monthly*(18) where the following heading occurs:—

> NO MORE LAND AVAILABLE AT SOGERI, PAPUA.
>
> At the request of the planting interests, the Government has recently investigated the possibilities of the Sogeri District for further development. Three officers of the service made an extensive survey of the district and the hinterland beyond.
>
> From their reports it appears that the area of land believed to be available for settlement has been exaggerated, and that there is very little suitable for development beyond two comparatively small areas used by the natives for their hunting grounds. Beyond these areas the country is rocky and precipitous, in some parts rising to a high wall of rock over which extend further rocky ranges.
>
> Thus it would appear that further extension of development in the district is impracticable.

It would appear that such a survey, as with any other economic survey conducted in either this Territory of Papua, requires a soil survey conducted by a soil chemist; also a careful review of the possibilities by a qualified rubber man. A survey under other circumstances may or may not be correct.

If large additional areas suited to rubber planting do exist in that district, there seems to be little doubt that only lack of enterprise would preclude the provision of better transport facilities. The cost of transport adds to the cost of production and this is one reason why rubber costs there are higher than in Malaya.

PAPUA: AREA UNDER CULTIVATION AND IN TAPPING.

Such complete particulars of the areas under rubber cultivation in Papua for the various years as for tonnage and value of rubber exported are not available in this Department. It is possible, however, to trace the trend of developing the industry from the figures on hand.

Up to about 1906 very little *Hevea* rubber had been planted in Papua and it was not until the years 1909-10 that any noticeable area was planted. The total area under cultivation for all crops in Papua, in 1907, was only 1,067 acres and this area was probably mainly coco-nuts.

By 1908 the total area had been quadrupled to 4,955 acres, of which a fair proportion was probably under rubber; 3,808 acres of rubber out of a total of 7,740 acres (or nearly 50 per cent. of the total acreage) had been planted by 1909-10.

It might be pointed out that 3,808 acres represents practically a quarter of the area under rubber in 1939-40.

By 1912-13 the total area under cultivation had increased to over 35,000 acres of which 6,275 acres (equal to 19 per cent.) were under rubber. This corresponded to about half the 12,964 acres of rubber planted up to 1939-40, i.e. 27 years later.

TABLE No. 3.—AREAS UNDER CULTIVATION IN PAPUA.

Year.	Total Areas Planted.	Area taken up for cultivation of Rubber.	Area taken up for cultivation of Coco-nuts.
1907	1,467	*	*
1908	4,955	1,698	5,365
1909	7,740	1,886	6,716
1910	10,053	2,889	9,513
1911	15,881	4,496	15,993
1912	24,707	6,256	21,958
1913	35,303	6,606	29,030
1914	42,921	6,203	32,722
1915	44,447	7,671	34,016
1916	44,959	7,760	34,686
1917	47,319	8,311	42,675
1918	57,593	8,598	43,560
1919	58,347	8,363	46,101
1920	62,162	7,250	44,328
1921	60,314	7,465	46,515
1922	60,044	7,171	46,360
1923	60,863	7,481	46,797
1924	61,180	7,846	48,022
1925	62,981	7,728	50,506
1926	63,000†	7,981	50,218
1927	61,370	8,212	49,244
1929	60,136	8,804	48,363
1929	59,487	9,012	49,072
1930	58,904¼	9,075½	47,838
1931	61,219	10,320	49,413
1932	59,751	8,796	49,305
1933	58,244¼	8,993	47,921
1934	59,445	8,933	49,032
1935	58,628	9,591	47,641
1936	59,945	10,270	48,188
1937	57,636	11,836	45,207
1938	59,945	12,809	44,188
1939	..	12,964‡	..

* No record.
† Approximately.
‡ Actual area under cultivation, according to latest Annual Report of Department of Agriculture, Papua.

N.B.—There are practically no records of the actual area under cultivation for rubber and coco-nuts in Papua. The figures presented in the Papuan Annual Reports represent areas actually taken up for cultivation of such crops as given in the above Table.

The acreage of rubber remained relatively stable, around 7,250 acres, from 1919 to about 1928-29, when it was increased to 8,804 acres, and again to 9,012 acres in 1930-31, and by 1935-36 another 500 acres had been added, thus bringing the area under rubber to 9,591 acres. Since that time, a fairly rapid development has occurred, about 3,353 acres being added to this total in the four years ending 1939-40, and the development is still continuing. This position should be compared with the acreage planted between 1912-13 and 1934-35, when in the previous 22 years the acreage increased from 6,275 to 9,591 acres—an increase of 3,216 acres.

Reference to Table No. 3 will show that the total area under cultivation in Papua for all crops has increased very little since 1919 (58,347 acres then, compared with 59,945 in 1938). The same applies to the area under coco-nuts, which has tended to decrease, if the figures given are correct, probably due to old areas being abandoned.

Reference to Table No. 4 gives particulars of rubber-producing districts in Papua. This table shows that the main rubber-producing districts are in the Central and Eastern Divisions. The Central Division, with Port Moresby as the shipping centre, contains easily the most important rubber-growing areas in Papua, as five-sixths of the whole planted area (10,121 acres) are in this division. In the next important area, the Eastern Division, with Samarai as centre, 852 acres are planted, while the Delta and Northern Divisions rank next with 690 and 542 respectively under rubber cultivation. There are also relatively small areas in the Western and Gulf Divisions. No rubber is planted in the South-eastern Division, which includes the Louisiade Archipelago and other islands, or North-eastern Division adjoining Morobe. It would seem from the areas recently taken up for rubber-planting that more extensive planting is now being carried out in the coastal districts and more attention being paid to the Northern Division.

The western part of Papua for 300 miles along the coast is generally low and swampy, mangroves and sago-palm being prominent features of these swamps. The delta country of the Fly and Purari Rivers are represented in this area.

TABLE No. 4.—RUBBER PLANTATION STATISTICS—PAPUA.
ACREAGE IN VARIOUS DISTRICTS.

Division.	Year.					
	1925.	1927.	1930.	1933.	1937.	1938.
Central	6,089	6,350	7,329	6,814	7,966	10,121
Eastern	868	889	880½	804	944	852
Delta	445	605	449	625	629	692
Gulf	15	42	131	268	268	268
North Eastern (adjoining Morobe) ..	..	..	..	..	..	..
Northern	165	165	125	153	133	542
South Eastern (Louisiade Archipelago)	..	..	..	..	..	..
Western	146	161	161	329	300	334
Total	7,728	8,212	9,075½	8,993	10,240	12,809

N.B.—These Statistics may represent areas taken up only; they appear somewhat unreliable.

Acreage of Rubber Planted in Various Districts.

Table No. 4 shows the relative development of rubber-planting in the various districts by comparing the years 1925, 1927, 1933, 1937 and 1938. It will be seen that the greatest development of rubber-planting is in the Central Division, where 10,121 acres of rubber were planted by 1938, and this represents an increase of 4,000 acres since 1925.

The position in the Eastern Division, where the next largest area is planted, appears to have altered very little in that time.

In the Delta Division there has been an increase of about 250 acres since 1925, while in the Gulf Division there has also been a similar average increase on a much smaller total, namely, from 15 acres to 268 acres, and this is likely to increase further.

In the Northern Division there was no increase in planting until quite recently, when 400 acres of rubber were added between 1933 and 1938, apparently around Kokoda. This Division now has twice as much under rubber as the Gulf Division, whereas five years ago the position was reversed.

The Western Division showed an acreage increase of almost 300 acres between 1925 and 1933; since that time, there has been practically no development, unless it occurred very recently, or in the South-eastern Division, which includes the Louisiade Archipelago and other islands.

TABLE No. 5.—PAPUA—PARTICULARS OF AREAS PLANTED.

—	1938-39.		1939-40.	
	Acres.		Acres.	
Area under lease for rubber growing	77,411		..	
Area being tapped	7,224		7,904	
Area being planted, not yet tapped	5,585		5,060	
Area planted	12,809	14,433	12,964	14,494
Area cleared	1,624		1,530	
Area undeveloped	62,978		..	
Total	77,411		..	

The calculations for the area being tapped were made as follows:—The rubber production for the year was 1,290 tons. Assuming the average production per acre per annum to be 400 lb., the area being tapped is estimated to be approximately 7,224 acres. The statistical position of the rubber plantings was thus stated as given.

In the Annual Report of the Department of Agriculture, 1939-40, the following particulars are given. During the month of May, 1940, an opportunity was taken to circularize planters for the purpose of ascertaining the position of the rubber industry in the Territory, details of which are as follows:—

TABLE No. 6.—AREAS OF RUBBER—PAPUA.

Number of producing plantations	23
Total area cleared for rubber cultivation	14,494 acres
Area planted with rubber	12,964 acres
Area being tapped	7,904 acres
Area not at tapping stage	5,060 acres

The annual production of the tappable area is estimated at 3,009,379 lb. (rubber exports—1,345¾ tons).

Yield Per Acre—Papua.

Taking the above figures as a guide, the average yield per acre is 380 lb.; but, according to the Director of Agriculture, Papua, this figure is rather misleading, as some plantations produce as much as 500 to 520 lb. per acre, whilst in an isolated instance the yield was given as 1,428 lb. This latter yield may appear somewhat fantastic. It would seem that the explanation is that the trees on this particular area are very old and have not been tapped for many years (also probably tapped very heavily).

Land and Surveys.

During the year, applications were received for 23,239 acres of land, of which 21,814 acres were granted; of these, 21,603 acres were for rubber, and only 111 acres for coco-nuts. The low price of copra has had the natural effect of discouraging investment in coco-nut plantations in Papua, and the more favorable prospects for rubber have had the effect of diverting the attention of investors to this culture.

The total area of land now held under lease for the cultivation of rubber exceeds 70,000 acres (77,411 acres).

In 1936-37, there were nineteen applications for 29,120 acres of land for rubber-planting, of which 25,372 acres were granted.

TABLE No. 7.—PRIMARY PRODUCTS—EXPORTS FROM PAPUA, 1928-1939.

(Comparative Table.)

——		1927–28.	1928–29.	1929–30.	1930–31.	1931–32.	1932–33.
Copra	Tons	9,825	12,480	11,693	9,436	10,011	9,686
Value (Diminishing) ..	£	194,019	214,051	176,485	93,710	100,454	89,512
Desiccated coco-nut ..	Tons	108	261	747	1,467	1,228	1,118
Value	£	7,407	16,033	39,923	79,264	59,826	49,514
Rubber	Tons	811	470	764	785	806	953
Value (Rising)	£	102,158	46,816	50,640	47,036	49,262	56,929
Coffee Beans	Tons	..	4	5¾	2¾	8¼	36¼
Value	£	..	313	519	242	537	2,404
Cocoa Beans	Tons	2,660	784	..	..	..	..
Value	£	149	17	..	..	..	..
Tobacco	Tons	..	..	..	..	2,085	..
Value	£	..	..	..	..	216	..
Cotton	Tons	1	3.7	2	½	..	..
Value	£	59	415	167	28	..	..
Grain Pulse	Bushels	..	..	..	24	22	34
Value	£	..	..	..	956	782	1,379
Hemp	cwt.	..	..	1¼	135	..	..
Value	£	..	..	3	271	..	..
Timber ..	super. feet	13,783	2,105	183	396	4,689	9,163
Value	£	276	59	7	12	47	351
Bark—Mangrove ..	Tons	5½ (cwt)	..	..	..	..	10
Value	£	18	..	..	..	..	41
Gum	Tons	76	28	58	16	22	14
Value	£	1,955	593	1,377	519	532	274
Sandalwood	Tons	21	6	97½	28	91¾	25¼
Value	£	424	225	2,779	716	2,523	536
Gold	oz.	2,173	2,281	5,634	6,923	8,574	15,268
Value	£	6,364	6,767	10,632	22,440	34,338	45,383
Total Exports, Value*	£	350,363	337,365	342,775	274,354	269,354	275,866

* Includes other items—chiefly shell and minerals.

TABLE NO. 7.—PRIMARY PRODUCTS—EXPORTS FROM PAPUA, 1928-1939—*continued.*
(Comparative Table.)

		1933–34.	1934–35.	1935–36.	1936–37.	1937–38.	1938–39.
Copra	Tons	8,082	8,570	10,549	13,600½	11,249¼	9,357¼
Value (Diminishing)	£	42,990	57,597	100,681	191,808	91,166	57,999
Desiccated coco-nut	Tons	1,274	1,453	1,415	1,498¾	1,541¼	1,580½
Value	£	48,000	37,895	42,467	47,137	52,628	48,140
Rubber	Tons	948	1,069	1,097	1,112½	1,243	1,290
Value (Rising)	£	61,324	79,031	89,467	124,174	129,448	114,949
Coffee Beans	Tons	60½	79	54½	88	83¼	111¾
Value	£	4,994	7,083	5,217	7,536	6,606	6,911
Cocoa Beans	Tons	..	..	..	..	..	..
Value	£	..	..	..	..	..	..
Tobacco	Tons	458	..	..	..	..	..
Value	£	11	..	..	..	..	..
Cotton	Tons	..	..	..	..	..	..
Value	£	..	..	..	..	..	..
Grain Pulse	Bushels	1,636	1,269	828	481	896	558¾
Value	£	1,683	1,079	620	424	727	421
Hemp	cwt.	..	..	..	..	..	..
Value	£	..	..	..	..	..	..
Timber	super. feet	10,095	14,485	4,672	1,159	4,618	5,578
Value	£	167	222	77	9	92	119
Bark—Mangrove	Tons	..	60¼	15	138¾	200¼	173¼
Value	£	..	337	68	694	1,002	875
Gum	Tons	36	49	30	47¾	73½	65¾
Value	£	727	1,032	650	1,056	2,248	1,576
Sandalwood	Tons	103½	171¾	8¼	7	..	..
Value	£	2,699	5,548	268	85	..	..
Gold	oz.	19,496	21,732	26,199	33,580½	41,308½	64,622
Value	£	45,933	68,922	81,034	87,003	108,141	150,198
Total Exports, Value*		249,135	294,743	355,157	524,001	435,593	490,158

* Includes other items—chiefly shell and minerals.

Number of Plantations in Papua.

In answer to a recent inquiry from this Department to the Department of Agriculture in Port Moresby, we were advised that there are 85 major plantations devoted solely to coco-nuts in Papua and 29 plantations with rubber as the sole crop (of which 24 are at the productive stage). There are six plantations producing coco-nuts and rubber in combination. There are also many small holdings on which are planted very small areas of coco-nuts and rubber, but these could hardly be termed plantations.

Importance of the Rubber Industry to Papua.

Rubber production is of decided economic and national importance to Papua, although the production is not yet on a particularly large scale. Reference to Tables 7, 8 and 9 and Graphs I., II. and III. clearly indicates this fact and, at the present time, rubber exports yield between 20 and 25 per cent. of the total income and returns approximately £120,000 per annum to that territory.

The importance of rubber to the internal economy of Papua would be much more in evidence if the gold yields had not also increased in late years, due to new development and increased price of gold. The money expended in oil prospecting has also tended to hide this fact.

It is fortunate that during the period when the income from copra had declined rubber has come to the fore to increase the income and balance the loss from this source. It must be remembered that when rubber is at a low price, copra yields a far larger proportion of Papua's income than at present. The main fear is that the present high prices will not hold and that, after a period of prosperity, depression conditions such as existed from 1929-35 may recur.

Table No. 7 presents details of the exports of primary products from Papua since 1927-28, and it is seen that the four main exportable products are gold, rubber, copra and desiccated coco-nut. Coffee and timber are the only other crops worthy of mention. Graph No. I. shows the quantities and Graph No. II. the values of the four main exports mentioned above. In general, gold production shows a rapidly increasing trend both in quantity and value and with present high prices is the most important export from Papua. Copra has been the most important product from Papua until the last couple of years, when rubber has come to the fore owing to prevailing high prices and increased demand.

TABLE No. 8.—PAPUA—RUBBER PARTICULARS.

Year.	Acreage.	Tons Exported.	Value.	Year.	Acreage.	Tons Exported.	Value.
		Tons. cwt	£				£
1895–96	Probably mainly wild rubber	0 6	..	1918–19 ..	(a) 8,598	207	33,010
1896–97		0 16	..	1919–20 ..	(a) 8,363	242	41,542
1897–98		0 13	..	1920–21 ..	(a) 7,250	220	28,966
1898–99		0 7	..	1921–22 ..	(a) 7,465	85	5,862
1899–00		(b)	..	1922–23 ..	(a) 7,171	57	5,907
1900–01		(b)	856	1923–24 ..	(a) 7,481	304	33,334
1901–02		(b)	928	1924–25 ..	(a) 7,846	511	68,507
1902–03		(b)	1,029	1925–26 ..	(a) 7,728	642	194,849
1903–04		(b)	498	1926–27 ..	(a) 7,981	761	156,274
1904–05		(b)	67	1927–28 ..	(a) 8,212	811	102,158
1905–06 ..	..	(b)	1,145	1928–29 ..	(a) 8,804	470	46,816
1906–07 ..	..	(b)	1,385	1929–30 ..	(a) 9,012	764	50,640
1907–08 ..	..	(b)	483	1930–31 ..	(a) 9,075½	785	47,036
1908–09 ..	(a) 1,698	(b)	113	1931–32 ..	(a)10,320	806¼	49,262
1909–10 ..	(a) 1,886	(b)	904	1932–33 ..	(a) 8,796	953¼	56,929
1910–11 (c)	(a) 2,889	(b)	2,054	1933–34 ..	(a) 8,993	948½	61,324
1911–12 ..	(a) 4,496	(b)	935	1934–35 ..	(a)	1,069¼	79,032
1912–13 ..	(a) 6,256	(b)	517	1935–36 ..	(a) 9,591	1,096¾	89,467
1913–14 ..	(a) 6,606	8 0	1,536	1936–37 ..	10,270	1,112½	124,174
1914–15 ..	(a) 6,203	1 0	1,501	1937–38 ..	11,836	1,243	129,448
1915–16 ..	(a) 7,671	43½ 0	14,486	1938–39 ..	12,809	1,290	114,949
1916–17 ..	(a) 7,760	85 0	26,682	1939–40 ..	12,964	1,345¾	..
1917–18 ..	(a) 8,311	144.7 0	37,020				

Papuan estimates are incomplete.

(a) The area given for rubber in Papua—means the area taken up for cultivation of the product and only in certain instances, e.g., 1939–40 are the true estimates given. (b) Not available. (c) In 1910–11, 3,808 was probably the true acreage planted.

The amount of copra produced has remained relatively stable since about 1929; the fluctuations appear to be dependent on the price received. These fluctuations are probably due to more "trade" copra being included when prices are high just as happens in the Territory of New Guinea.

It will be seen that the value of copra exports held pride of place until 1934-35 when for two years the value of rubber exports showed a considerable gain. In the following two years, however, copra again established an easy lead as to value of production. For the last three years, rubber has easily been the most important agricultural export and is likely to remain so during the war period.

Papua.—Fluctuations in the Amounts of Rubber Exported and the Value of Crude Rubber Production.

A reference to Table No. 8 will show the rubber acreage, the amounts of rubber exported and the value of the crude rubber production from Papua, as far as particulars are available. The amounts and values of copra exports together with the total value of exports from Papua are tabulated for comparative purposes in Table No. 9.

The tonnage, value of rubber exports and the acreage planted have shown a gradual increase over the years. It is seen, however, that although the commencement of rubber planting in Papua was not far behind that in other tropical countries, the industry did not expand rapidly. It would appear that there were various reasons, which were mainly economic, such as the type and amount of labour available, age of the colony and because there were not expansive areas of alluvial or new volcanic land readily available.

In common with other countries, depression periods have had a marked effect on the quantities and values of rubber exports. Copra tonnage and value of exports have not shown such marked fluctuations at similar periods, although the same trends were present. It would appear that, from the figures presented, there has been either little encouragement or little attempt to expand this industry in Papua over the past ten years.

TABLE No. 9.—PAPUA: YEAR FLUCTUATIONS IN TONNAGE AND VALUE OF RUBBER AND COPRA EXPORTS.

Year.	Rubber Exports.			Copra Exports.			Total Exports, All Primary Products, Value.
	Quantity.	Value.	Total Exports.	Quantity	Value.	Total Exports.	
	Tons.	£	Per cent.	Tons.	£	Per cent.	£
1916–17 ..	85	26,682	16.40	2,096	40,882	26.1	156,535
1917–18 ..	144.7	37,020	16.7	3,189.7	68,225	30.8	221,699
1918–19 ..	207	33,010	18.7	2,598	53,264	30.21	176,247
1919–20 ..	242	41,542	15.45	4,080	124,035	46.0	270,481
1920–21 ..	220	28,966	16.8	2,984	68,579	39.7	172,672
1921–22 ..	85	5,862	2.66	5,063	87,377	39.6	220,236
1922–23 ..	57	5,902	3.3	5,870	112,481	62.7	179,452
1923–24 ..	304	33,334	14.0	7,315	136,659	57	239,498
1924–25 ..	511	68,507	18.6	7,765	172,905	47	367,629
1925–26 ..	642	194,849	28.4	8,619	204,097	29.7	685,896
1926–27 ..	761	156,274	34.4	9,542	186,837	41.1	454,462
1927–28 ..	811	102,158	29.2	9,825	194,019	55.4	350,363
1928–29 ..	470	46,816	13.8	12,480	214,051	63.4	337,365
1929–30 ..	764	50,640	15.5	11,693	176,485	54.3	324,775
1930–31 ..	785	47,036	17.1	9,436	93,710	34.1	274,354
1931–32 ..	806	49,262	18.2	10,011	100,454	37.3	269,354
1932–33 ..	953	56,929	20.6	9,686	89,512	32.8	275,866
1933–34 ..	948½	61,324	24.7	8,082	42,990	17.2	249,135
1934–35 ..	1,069¼	79,032	26	8,570	57,597	19.5	294,743
1935–36 ..	1,096¾	89,467	25.2	10,549	100,681	28.3	355,157
1936–37 ..	1,112½	124,174	23	13,600½	191,808	36.6	524,001
1937–38 ..	1,243	129,448	24.25	12,249¼	91,166	20.1	435,593
1938–39 ..	1,290	114,949	20.6	9,357¼	57,999	11.8	490,158

It was not until 1915-16 that Para rubber exports showed any particular volume and, by the following year, the amount and value of these exports had almost doubled. There were also considerable increases in the tonnage exported, but not of values in 1917-18 and 1918-19. In 1919-20 the record tonnage (242 tons) and value (£41,542) in the six-year period of high prices, ranging from 1916 to 1921, was exported and then followed a sharp drop in the value of exports in 1920-21, when 220 tons of rubber brought £29,000 (approximately).

In 1921-22 and 1922-23 there was a disastrous slump in the rubber industry when in the first of these seasons only 85 tons of rubber valued at £5,826 was exported and in 1922-23 the exports fell to 57 tons sold for approximately the same value.

In 1922-23, according to the Annual Report,(19) the London prices for plantation sheet rubber were so low during the early part of that financial year that practically all plantations ceased tapping. This resulted in a great loss to owners and a serious decline in the wealth of Papuan production.

It was commented that instead of 57 tons the production should have been approximately 660 tons, as the 7,171 acres planted had then practically all reached a tappable stage.

During 1923-24, with increase in prices, the exports rose to 300 tons valued at £33,000 (approximately). There was a marked increase in tonnage, but especially in value, up to the year 1925-26, when 642 tons brought £194,849, and good prices and returns prevailed for a period of four years. The 1925-26 season still remains the record year for Papuan rubber exports, despite the fact that the quantity of rubber at present exported annually doubles this amount (cf. 1,287 tons in 1938). The quantities and values of rubber exported during the years 1926-27 and 1927-28 remained very satisfactory.

In 1928-29 another sudden and sharp decline occurred and the value of rubber exports slumped from £102,000 in 1928 to £47,000 approximately in 1929. This decline ushered in a long period of depression of rubber values which, besides being responsible for the increased application of rubber restriction in the larger producing countries, led to the granting of legislative assistance in Papua, namely, the "Grant in Aid" provided in November, 1930.

This state of affairs lasted for six years and it was not until the end of 1933 and in 1934-35, when nearly 1,100 tons of rubber valued at approximately £90,000 were sold, that a favorable period for the rubber producers commenced. The "Grant in Aid" was then reduced from 4d. to 2d. per lb. in September, 1933, and was finally discontinued in September, 1936. According to the Commonwealth *Year-Book* (1936) the improvement in price, coupled with Australia's preference, was responsible for the increased exports of rubber during the two years to 1936.

The quantity and value of rubber sheets exports have continued to improve in the main since 1934 up to the present time. The producers have thus experienced approximately six years of prosperity and of these the last four years have been really prosperous years, even allowing for some slight, temporary declines in values at intervals.

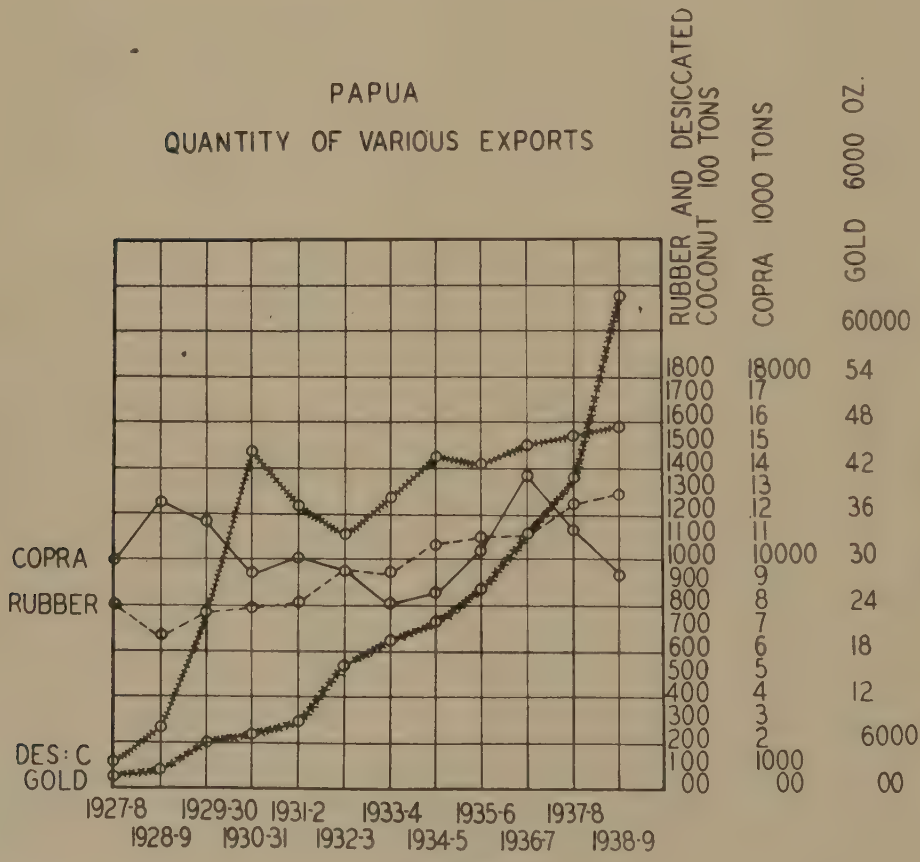
It is readily apparent why producers and intending investors wonder how long this cycle of good years will last and recognize the need for some form of stabilization of the industry. This will be especially likely when the present heavy demands due to war requirements are met.

Reference to Graph No. III. shows, in a comparative way, how the peak and slump periods in copra exports and values roughly corresponded, though to a lesser extent, with those of rubber production and values in Papua. It may be of interest to note that, although much more copra is exported from the Mandated Territory, the peaks and curves in the copra graph, for value exported, *see* Vol. 2, No. 2, *New Guinea Agricultural Gazette,* closely paralleled the fluctuations in Papuan figures.

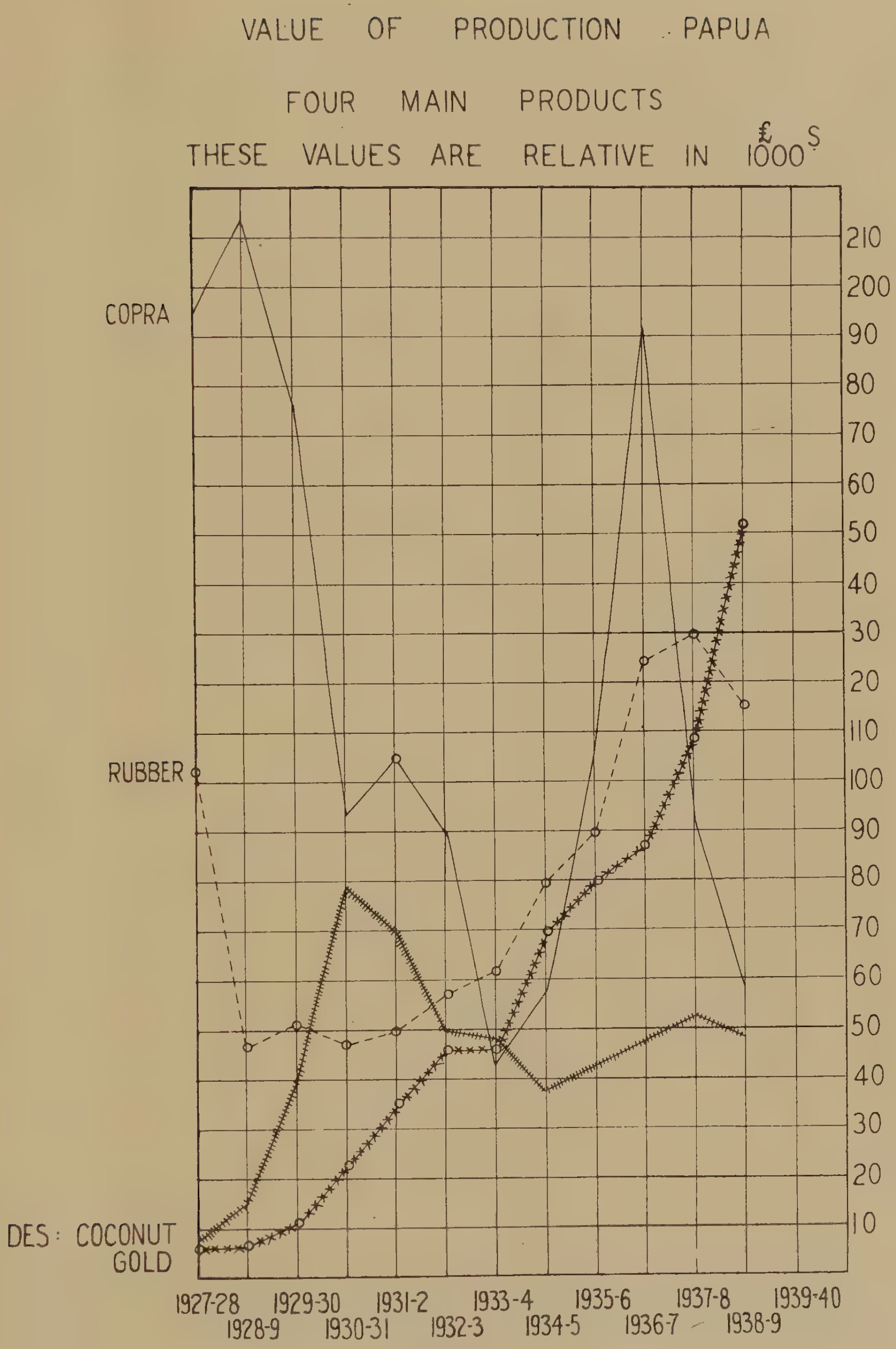
In the Papuan Annual Report for the year 1938-39,(20) the following remarks on rubber appear:—

> Activity in agriculture for the twelve months just concluded (1938-39) has been well sustained and particularly does this apply to rubber growing. The cultivation of rubber in this Territory has now reached comparatively large proportions, and it is to be hoped that the market price of the product remains favorable and thereby rewards planters for the considerable amount of energy and money that has been spent in furthering the industry. Whilst the rubber market has been somewhat erratic, there appears to be no indication in the fluctuations that we are faced with any other than a remunerative market, rather the London market price at the time of writing would tend to forward the view that for some time at least, rubber can be profitably cultivated.

[*To be continued.*]

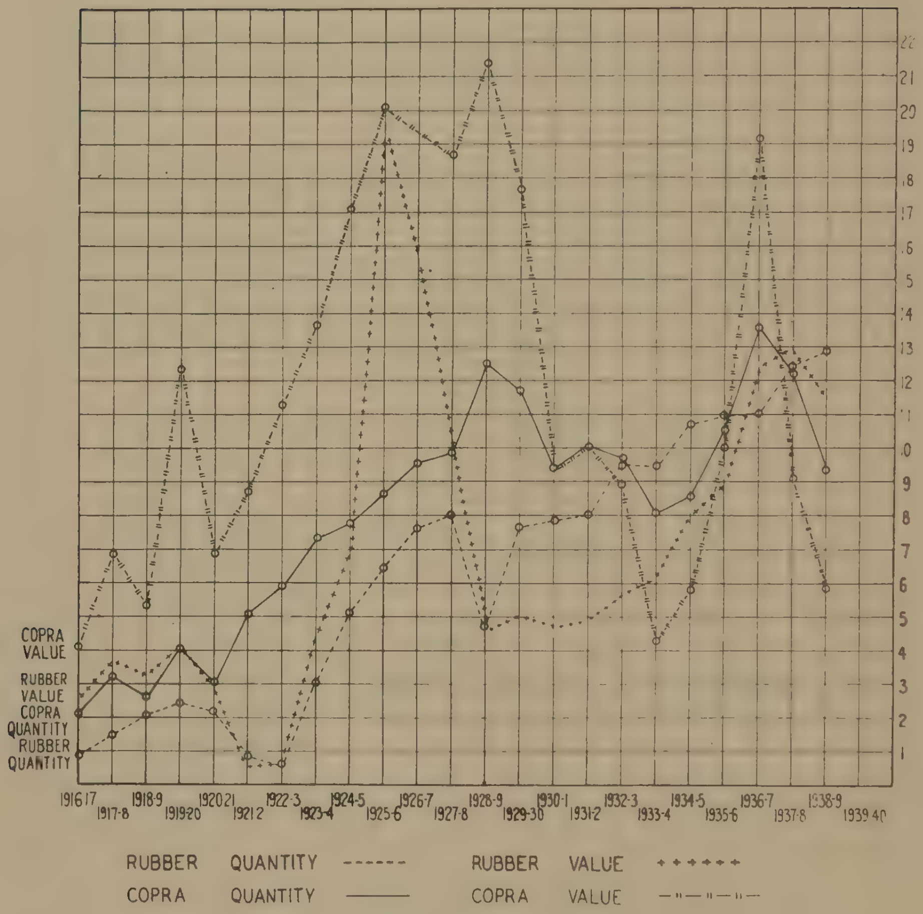


Graph No. I.


VALUE OF PRODUCTION PAPUA
FOUR MAIN PRODUCTS
THESE VALUES ARE RELATIVE IN £1000S
COPRA
RUBBER
DES: COCONUT
GOLD
210
200
90
80
70
60
50
40
30
20
110
100
90
80
70
60
50
40
30
20
10
1927-28
1929-30
1931-2
1933-4
1935-6
1937-8
1939-40
1928-9
1930-31
1932-3
1934-5
1936-7
1938-9

Graph No. II.

PAPUA YEARLY FLUCTUATIONS IN TONNAGE AND VALUE OF RUBBER AND COPRA EXPORTS



Graph No. III.

COCO-NUT JOURNAL.

A copy of Volume I., Number I., of the *Coco-nut Journal* was recently received. This journal is published by the National Coco-nut Corporation, Soriano Building, Manila, and the subscription rate is 2 pesos per annum. The journal is most attractively presented and should prove of great value to all interested in the welfare of the coco-nut industry.

THE DIFFERENT CLASSES OF FERTILIZERS.

The number of different fertilizers offered from all sources to the farmer is legion, but he who reads and studies these pages will be in a position to differentiate and to choose those which will be of most value to himself, for he will learn that a good fertilizer must be valued according to its content of nitrogen, phosphoric acid, and potash.

The cheapest fertilizer is not the one costing least per ton, but is that in which the nitrogen, phosphoric acid, or potash, in a form available to the plants, costs least. It is, therefore, necessary to know the chemical composition of a fertilizer in order to determine whether it is worth its price.

Although the organic matter present in a fertilizer is not to be considered as a plant food, it is by no means to be considered as valueless. It has a good effect on the physical character of the soil, as it augments the supply of humus. It is partly for this reason that farmyard manure is so valuable.

Farmyard manure is a complete manure containing nitrogen, phosphoric acid and potash in quantities which depend upon its origin and treatment. An average content for slightly rotted first-class dung would be about 0.4 per cent. N, 0.2 per cent. P_2O_5, and 0.5 K_2O. In tropical countries, however, we must often reckon with far lower percentages. Farmyard manure offers to the plant each of the three principal elements required for successful growth.

In consequence of its high percentage of organic matter it exercises a very beneficial effect on the structure of the soil, and also on the bacterial life. The planter should, therefore, endeavour to avail himself of all the farmyard manure at his disposal, by collecting and keeping it very carefully. A drawback of farmyard manure, however, is that, if not properly kept, it may introduce germs of diseases into the plantation.

In some districts human excrement is used in the form of night-soil and, although the composition of this is not quite so favorable as farmyard manure, it may be regarded as a good complete manure.

In order to keep down the expenditure upon fertilizers, attention should be given to the utilization of all refuse of the plantation in the form of compost. Weeds and crop refuse should be heaped together and mixed with lime, which accelerates their decomposition. The manurial value of compost is increased very materially if phosphoric fertilizers and potash salts are mixed with the heap, at the rate of ½ cwt. muriate of potash, and ½ cwt. basic slag to the cubic yard. Compost is used to the greatest advantage when applied to the seed beds. The danger of introducing weeds and pests into the plantation has also to be considered when using compost.

Owing to the comparative scarcity of farmyard manure on tropical plantations, often the only way the planter has of enriching the soil in humus is to grow green manure crops of the leguminous family and to plough them under. This practice is very beneficial on stiff clays and on light sandy soils, as the introduction of organic matter helps to loosen the texture of the former and to bind the latter, thus improving the physical condition of both types of soil. By growing green crops between the main crops, instead of letting the land lie fallow, the planter can keep his soil free from weeds and protect it from the leaching action of the heavy rains.

Besides adding humus to the soil, green manuring also enriches the soil in nitrogen. This is a very great advantage to the planter, especially since nitrogen is the most expensive plant food, costing four or five times as much per unit as either potash or phosphoric acid. The gaseous nitrogen, which forms four-fifths of the atmosphere, is valueless as far as the nutrition of plants is concerned, since they cannot make use of it in this form. The legumes (e.g., peas, beans, clover, lucerne, &c.), however, are an exception to this general rule. On the roots of leguminous plants are nodules containing bacteria, which, while living as parasites and feeding on the carbohydrates provided for them by the plant, fix the nitrogen of the atmosphere and convert it into suitable plant food for their host. It has been calculated that a good green crop brings more nitrogen into the soil than a good dressing of nitrogen fertilizer. As a source of nitrogen, green manure has the further advantage, that it yields a steady supply of nitrogen, at the rate at which the latter is required by the main crop, because the time during which the crop grows most vigorously and requires large supplies of plant food, coincides more or less with the period when the soil bacteria are most active in converting the organic matter of the decaying green crop into available plant food. It is therefore evident that green manuring is not only the best way of improving soils which are lacking in humus, but is also an economical and efficient means of enriching the soil in nitrogen.

To the class of organic fertilizers also belong pressed cakes made from oil seeds during the oil extraction. The quantity of organic matter brought into the soil by applications of cake is not very high, nor are cakes a complete manure. They give chiefly a one-sided manufing of nitrogen, which although in a form not immediately available to the crop, is transformed by bacteria into nitrate. Its absorption by the plant is dependent upon the velocity with which the cake is decomposed by the bacteria of the soil.

Such manures will not exercise so rapid an effect as mineral manures, but this is not necessarily a disadvantage, since for perennial crops such as tea, rubber, and coco-nut, it is of great advantage to have a fertilizer which will act in a gradual and lasting way. The most important of these are soya bean cake, castor cake, rape cake, cotton cake.

Of a similar effect are some by-products of animal origin which are of importance chiefly as sources of nitrogen and phosphoric acid; among these are dried blood, tankage, bone dust, and fish meal. Guano, though of organic origin, is, in most cases, already more or less mineralized, being the fossilized excrement of birds or bats. The best of the Peruvian guanos contain nitrogen and phosphoric acid, but most of other guanos contain only phosphate in a rather insoluble form, and are to be considered more or less as rock phosphates, which require treatment with sulphuric acid to render them soluble.

The following analyses show the average percentages of the four manurial constituents contained in the principal organic manures:—

——	Nitrogen.	Phosphatic acid.	Potash.	Lime.
	Per cent.	Per cent.	Per cent.	Per cent.
Farmyard manure	0.39	0.18	0.45	0.49
Human excrements	0.55	0.28	0.20	0.10
Ground nut cake	7.60	1.30	1.50	0.20
Soya bean cake	6.90	1.50	1.10	..
Cotton cake	6.20	3.10	1.60	0.30
Castor cake	5.50	0.75	6.50	..
Copra cake	3.33	0.50	1.12	..
Bone meal—				
Raw	4.00	20.25	0.20	31.30
Steamed	3.00	20.22	..	..
Fish meal	8.50	17.40	0.30	15.40
Tankage	5.80	17.40	0.30	22.30
Blood meal	11.80	1.20	0.70	0.80
Horn meal	10.00	9.00	..	..

The several organic manures dealt with above may locally be very cheap sources of plant food. As, however, their composition is very variable, it is advisable that the planter who wishes to buy those that are obtainable should first have them analysed, so that he may know their composition.

The planter must always remember that cakes and by-products generally are not complete manures and being one-sided, they must be supplemented by the addition of some of the following mineral fertilizers, so that the plant may be provided with all the necessary plant foods in the right proportions.

The mineral fertilizers themselves are one-sided fertilizers and may be classed as nitrogenous, phosphatic and potassic.

The undernoted are the chief nitrogenous fertilizers in present-day use:—

Sodium nitrate—containing 15.5 per cent. nitrogen.
Calcium nitrate—containing 13 per cent. nitrogen.
Leuna salpeter (ammonium sulphate-nitrate)—containing 26 per cent. nitrogen.
Ammonium sulphate—containing 20.5 per cent. nitrogen.
Nitrolim—containing 18 per cent. nitrogen.
Synthetic urea—containing 46 per cent. nitrogen.

The nitrates of soda and of lime, also in part ammonium nitrate, contain the nitrogen in the form of nitrate, the form in which it is absorbed by the plant. In temperate climates this is very much in favour of these fertilizers, because the effect is thereby quicker and surer than that of the other nitrogenous fertilizers, the nitrogen of which must first be converted to nitrate by the bacteria of the soil.

In the tropics, however, this advantage seems to be of hardly any importance, because there nitrification proceeds so rapidly, that no objection can be made to sulphate of ammonia or nitrolim. It may even be that some crops benefit more from nitrogen in the form of ammonia.

Moreover, as sulphate of ammonia is not so easily washed out as nitrate, in tropical agriculture, it is often preferred to sodium nitrate.

As sources of phosphoric acid, in addition to the more or less mineralized forms of guano, the following phosphatic fertilizers are very much used:—

1. Superphosphate—containing 14–21 per cent. water-soluble P_2O_5.
2. Double superphosphate—containing 35–46 per cent. water-soluble P_2O_5.

3. Basic slag—containing 16–20 per cent. citric-soluble P_2O_5.
4. Rhenania phosphate—containing 25–30 per cent. citrate-soluble P_2O_5.
5. Ground rock phosphate—containing 25–35 per cent. insoluble P_2O_5.

Basic slag because of its lime content, is alkaline in reaction and is therefore preferred on acid soils, where the use of superphosphate might be dangerous. Rhenania phosphate contains about 25–30 per cent. P_2O_5 in a rather easily assimilable form.

The third important class of fertilizers is the potassic, containing potash in a form soluble in water. These are—

1. Sulphate of potash, 90–96 per cent. pure, containing about 48–52 per cent. pure potash.
2. Muriate of potash, 80–85 per cent. pure, containing about 50 per cent. pure potash.

Sulphate of potash, on account of the absence of chloride, is generally preferred for the manuring of crops rich in sugar or starch and also for tobacco—for high-class tobaccos the higher grade 96 per cent. sulphate, which has a guaranteed maximum content of 1 per cent. chlorine, is generally prescribed.

Another salt, sulphate of potash-magnesia, which contains about 26 per cent. of pure potash, is much favoured in European agriculture, because of its content of magnesia which according to modern investigation is also an important plant food. The good results obtained in Europe have led to its being tried in the tropics, but on account of its lower content of potash, and relatively high freight, it is less economic compared with, say, sulphate of potash.

The crude potash salts contain about 12–15 per cent. pure potash in the form of muriate of potash plus varying quantities of sulphate of magnesia and rock salt. Though these crude salts have been used with good results in Europe, freight makes their use in the tropics very costly. Kainit, however, is preferred by American cotton-planters and also for the manuring of coco-nuts, as the coco-nut palm is very responsive to a dressing of Kainit containing salt.

Nitrate of potash has the disadvantage that, in addition to the potash, a certain quantity of nitrogen in the form of the expensive nitrate must be bought. In experiments conducted in Java, the addition of nitrate of potash to oilcake depressed the manurial value of the cake, so that the manufacturers had to stop the practice of mixing oilcake and nitrate. Further, the negative results, which many potash experiments have given when potash was applied as nitrate, seem to indicate that nitrogen in this form reacted against the good effect of the potash.

Another potash fertilizer which seems cheap is wood ash. Its great disadvantage, however, is its varying composition and its low potash content of 2–10 per cent. potash (K_2O), which naturally means high costs of transport. It has been observed in certain experiments, that after a dressing of wood ash a strong growth of weeds was promoted, the destruction of which requires a great outlay. The check plots manured with sulphate of potash did not exhibit the same phenomenon.

As has already been pointed out, all these fertilizers are one-sided. In order, therefore, to provide a complete fertilizer, it is necessary to give them in combination as previously discussed. The mixing may be done by the planter himself, or he may buy a mixture ready made up from a reliable firm.

If the planter does the mixing himself, he will naturally save something on the cost of mixing, but he must be careful not to mix together substances which are incompatible. Such a mixture would lead to loss of nitrogenous elements or to reactions resulting in caking. As a rule it may be stated that lime or basic slag must not be mixed with sulphate of ammonia or nitrogenous organic manures, because the caustic lime in them would lead to losses of nitrogen; furthermore, lime and basic slag should not be mixed with superphosphate, because the water soluble phosphoric acid of the latter would combine with the lime and form insoluble phosphates, which are of much less manurial value. All the other fertilizers may be mixed. It is, however, to be recommended that the mixing be done only a short time before using, in order to avoid any possibility of caking.

The mixing is done by spreading one fertilizer on a hard surface and then distributing the second evenly over the first. By working the two together with a shovel a good mixture is obtained. If three are to be mixed, it is better first to mix two and then add the third to the mixture.

Where the planter prepares his own compound fertilizer, he has the advantage of knowing exactly its composition. A great number of very reliable firms exist which sell their compound fertilizers under guaranteed analysis. Most of these firms mix by machinery and are so able to offer very uniform mixtures at little extra cost. Consequently, most planters prefer to buy their fertilizers ready mixed. Where planters are in touch with reliable firms, they are recommended to buy from these, but in every case they should ask for the analysis, and make certain that they do not get a mixture from an obsolete formula containing, say, only nitrogen and phosphoric acid, but one also containing, in accordance with the demands of theory and practice, at least 4–1·5 per cent. potash.—(*Rewritten from a pamphlet by Jacob and Clyle, R.C.H.*)

IT PAYS TO FERTILIZE

Write or consult the Agricultural Chemist,
Department of Agriculture, Rabaul.

PREPARATION OF COCO-NUT SHELL CHARCOAL.

Details of various methods for the preparation of charcoal from coco-nut shells have already been published in this *Gazette* (Vol. 7, No. 1, Vol. 4, No. 2, Vol. 4, No. 1). Recently, another method which is being used successfully in this Territory and which has advantages over all the other methods so far described has come under notice. The shells are burnt in 40 gallon oil drums, the procedure being as follows:—

Preparation of Drum.

The drum should be free from any considerable leaks and if the bungs are of fusible metal they should be replaced by iron ones, or the bung holes closed by welding. The bottom should be cut out leaving a lip 2–3 inches wide around the outside. A circular cover is made of heavy galvanized or 16–20 gauge black iron and may be a flat disc or preferably slightly conical with a rise of about 3 inches in the centre. If a cone is made the seam must be welded or otherwise made airtight. The cover should be of such size that it will just fit inside the rim of the drum and rest on the 2 inch lip. A few (4–6) $\frac{1}{8}$ inch holes should be drilled round the top rim so that nails may be inserted to hold the cover in place when sealing the kiln. These holes must not be low enough to penetrate into the interior of the drum, thus allowing air leaks after sealing.

Site for Burning.

The drum is set up on level ground, preferably where it will be somewhat sheltered from any strong wind; but not so sheltered as to prevent air currents from reaching it. If improperly stoked the drum will give off dense volumes of white smoke, so that the burning should be done where the smoke will not become a nuisance. If stoked properly, there is practically no smoke.

Shells.

The shell should be clean, fresh, half-shells; old, rotten shells that have been lying about for months will give a low yield, and shells that have been wet with sea water must be excluded.

Starting up.

A single layer of shells is put in the bottom of the drum and a small fire of kindling wood started in the centre.

Burning.

As soon as the shells catch and begin to burn fresh shells are added, one at a time and at a rate controlled by the results produced. This rate of feeding is the important factor.

If the rate of feeding is too slow the shell will be over burnt. This can be judged by the colour of the flame which changes from yellow to bluish, and by the appearance of the charcoal which will be seen glowing and breaking into small pieces and becoming covered with white ash. The drums will also become intensely hot. The final product will have a low volatile content, but the yield of charcoal will be low.

Too fast a rate of feeding will extinguish the flame, and give rise to dense clouds of white smoke, the temperature of the drum will fall considerably and the fire will either be completely extinguished or give a product of half burned shell containing a high percentage of volatile matter. The yield of charcoal will, of course, be high under these conditions.

As the drum fills it will be found that a somewhat faster rate of feed can be maintained, especially if the shells are thrown in so as to stack up on the leeward side of the drum, where they become pre-heated before rolling down into the burning zone. It is advisable to have a torch, consisting of a roll of oil soaked bag or similar material handy, so as to ignite the gas again if it becomes extinguished through too rapid feeding. With continuous feeding about 300 lb. (5 sacks) of half shells can be burned in a 40 gallon drum in five hours, and one man can probably burn more than one drum at a time if drums and shell are conveniently arranged.

Finishing Off and Sealing.

When the drum is nearly full, the feeding of shell is discontinued, and burning continued until the yellow hypocarbon flame has practically disappeared, giving place to a blue or purple monoxide flame. When this point is reached the lid is put on, fastened down by inserting nails or wires and sealed by placing a few shovelfuls of earth on top. It is essential that the air be completely excluded from the charcoal during cooling. The drum and contents are then allowed to cool undisturbed—probably four to six hours will be necessary, for, if the burning has been properly conducted, the lower part of the drum will be cool by the time it is filled.

Opening up.

On opening up great care must be taken to avoid allowing earth to fall into the charcoal.

Yield.

A normal yield is 23–25 per cent., i.e. 70–75 lb. charcoal per drum, while the volatile matter in the charcoal should be between 5 and 15 per cent. R.C.H.

NEW COPRA CABINETS.

In a *résumé* of coco-nut and oil palm investigations being conducted at the Coco-nut Experiment Station, Port Swettenham, in Federated Malay States, published in Volume XXVIII., No. II., of the *Malayan Agricultural Journal*, the following information is given:—

> The new copra cabinets equipped with a jack-roof have proved highly efficient. A great saving in fuel is effected and the nut capacity per unit area of grill greatly increased. Three of these cabinets, Nos. 4A, 10A and 50A have been given systematic trials. No. 4A has a productive capacity of 3 piculs* per run and No. 10A of 7 piculs. No. 50A is a four-chamber kiln; each chamber has about the same capacity as that of No. 10A. With any of these new cabinets high-grade copra can be manufactured inside an overall time of two days, which is less than that at present necessary to obtain dry copra on existing kilns, either on estates or small holdings.
>
> Experiments have shown that the gross weight of wet meat is not the only factor to be taken into account when computing the load of a kiln. The thickness of the meat may also have to be considered.

At a later date, it is believed that Mr. F. C. Cooke intends to publish particulars of these types of kilns. The publication of his article is awaited with interest.

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* 1 picul = 133⅓ lb.

A SMALL OIL-MILL FOR THE TREATMENT OF COPRA.

In reply to a great many inquiries the following information has been obtained of two small oil-mills capable of extracting the oil from 6-7 cwt. of copra per hour (1,000 tons per year) and of a small oil refinery. These plants are unit plants of the smallest capacity advocated on a commercial basis.

The information was kindly supplied by Messrs. Rose, Downs and Thompson, Limited, Old Foundry, Hull.

Hydraulic Plant.

Copra is very rich in oil, the average oil content of good dry copra being approximately 65 per cent. and it is therefore customary to press this material twice. In large mills, this second pressing follows in additional machinery immediately after the first pressing, so that the copra proceeds immediately from the first to the second pressing. For the mill about to be described, it would not be an economical proposition to have this double form of mill for the first and second pressings as too much plant would be involved in comparison with the amount of work done. The method of working would be first to press the copra for its first pressing, allowing the cakes or residue, which still contain an appreciable percentage of oil, to accumulate for a few days until there are sufficient to justify going over to the second pressing. When this is to be done the supply of copra to the mill would be stopped. The first pressing cakes would then be broken up to meal and the process carried out in exactly the same way as for the first pressing. In this manner the maximum yield of oil is obtained, copra containing 65 per cent. oil yielding about 61 per cent.

The process will now be briefly outlined.

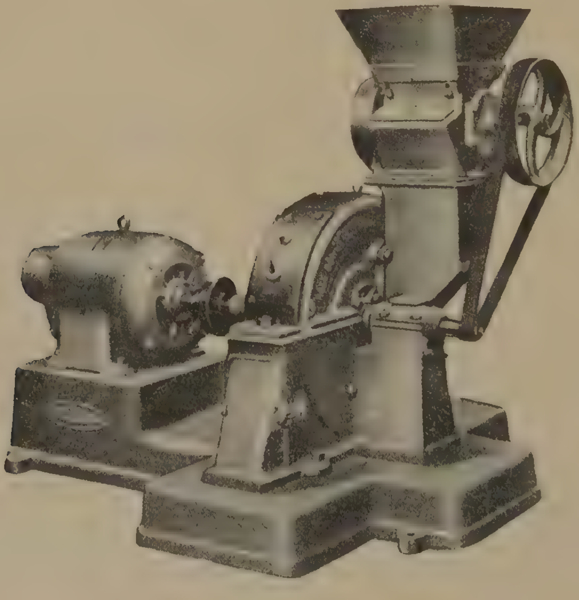

Figure I.

The copra is first fed to the disintegrator by means of the main feed elevator. The disintegrator fitted with a copra crusher feed is illustrated in Figure I. This illustration, however, shows an electrically driven machine whereas the machine quoted for later is belt-driven and would take its power from the main shaft of the mill.

The disintegrated copra would then be transferred to the feed hopper of a set of rolls by means of another elevator. These rolls, known as Anglo-American rolls, are employed for the grinding of the material into a meal prior to passing to the press. They are illustrated in Figure II.

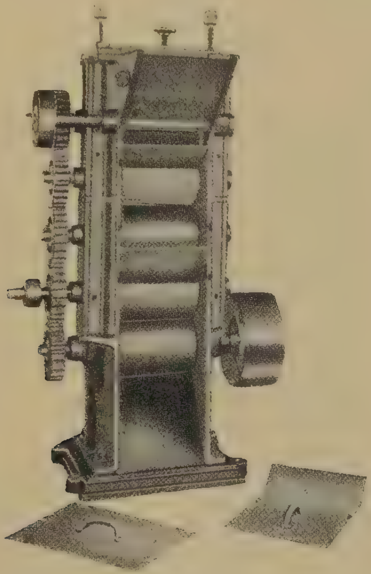

Figure II.

The rolled meal would then fall into another elevator and be lifted automatically to a kettle over the press. The purpose of this kettle is to cook and temper the meal before passing it to the pressing box of the press. With the temperatures which exist in New Guinea, this kettle could probably be dispensed with. A kettle and press are illustrated in Figure III. The press quoted for later is slightly larger than this.

After the meal has been pressed and the oil extracted, the oil would at once be pumped through a filter press for clarification purposes.

Figure IV. illustrates the type of filter which would be used. This filter is of the recessed plate type and has a steam-driven feed pump mounted on the head. As the oil flows away from the presses, it accumulates in a cistern from whence it is pumped away to oil-storage tanks.

Under normal conditions, when pressing copra the first time the weight would be reduced approximately 50 per cent. In other words, each ton of copra by the first pressing would produce approximately $\frac{1}{2}$ ton of first-pressing oil and $\frac{1}{2}$ ton of cakes which would contain an appreciable amount of oil and would therefore need to be pressed a second time. When the second pressing of these cakes is to be carried out, they are broken into meal. This would be done in the disintegrator, the cakes which are somewhat soft being first broken by hand and the pieces fed to the elevator which serves the disintegrator. The process would then be the same as for the first pressing.

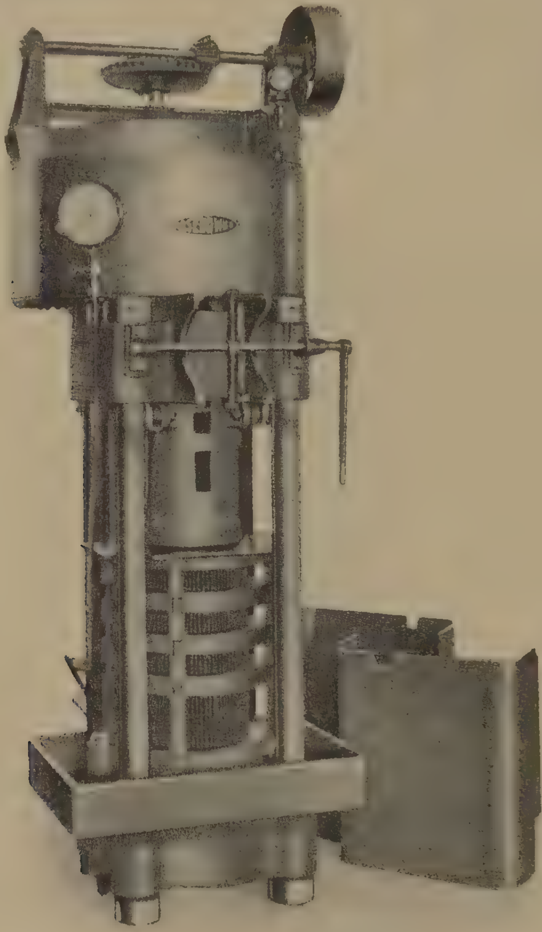

Figure III.

The approximate freight weight of the above plant would be 32¾ tons, all pieces and packages being under 2 tons dead weight. The power required to drive it would be 41 b.h.p. and the process steam 100 lb. per hour at 45 lb. per square inch.

Expeller Plant.

As an alternative to the hydraulic process referred to above, oil may be extracted by means of an automatic expelling process and generally speaking, it may be said that the yield of oil from copra would be the same as that resulting from the treatment of the material under hydraulic pressure. The expeller quoted for later is illustrated in Figure V. The preparation of the copra is carried out in the same manner for the expeller as for the press with the exception that the copra meal produced by the disintegrator would be quite suitable for the first pressing of the material in the expeller, so that, from the disintegrator this somewhat coarser meal goes straight to the kettle over the expeller and does not pass through a set of rolls. The copra is therefore fed by means of a main feed elevator to the disintegrator, and would then pass to the kettle over the expeller, where the meal would be thoroughly cooked and automatically pass to the pressing chamber of the expeller.

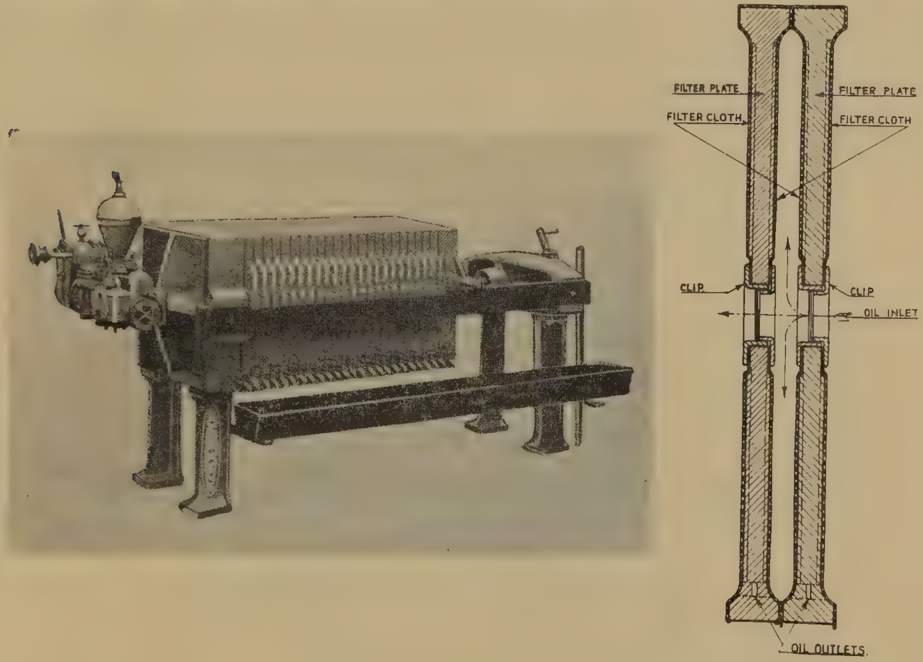

Diagram of two Recessed-type Plates

Figure IV.

The yield of oil from this first pressing would be practically the same whether pressed by an expeller or an hydraulic press and the flakes or residue from the expeller, which would still contain an appreciable quantity of oil would be allowed to accumulate for a few days and then be re-treated.

The first-pressing oil from the expeller would pass to a settling tank, where by gravity the foots and the meal which usually come away from an expeller are settled out, this settling tank forming a suction feed tank for the pump which serves the filter and the oil would be filtered in the same way as described for the hydraulic mill.

When treating the expeller flake or cake for the second pressing, the process would be slightly different in that it would first be broken to a meal in the disintegrator and would then pass through a set of rolls, it being necessary to grind the meal down to as fine a degree as possible.

The approximate weight of the above plant would be 18½ tons with one heavy lift 72 cwt. and the balance in packages each under 2 tons dead weight. The power required to drive it would be 39 b.h.p. and the process steam, 100 lb. per hour at 60 lb. per square inch.

Although the "Premier" mill works out somewhat more expensively than the single expeller mill, it will be noted that the capacity of this mill is slightly in excess of that for the expeller mill.

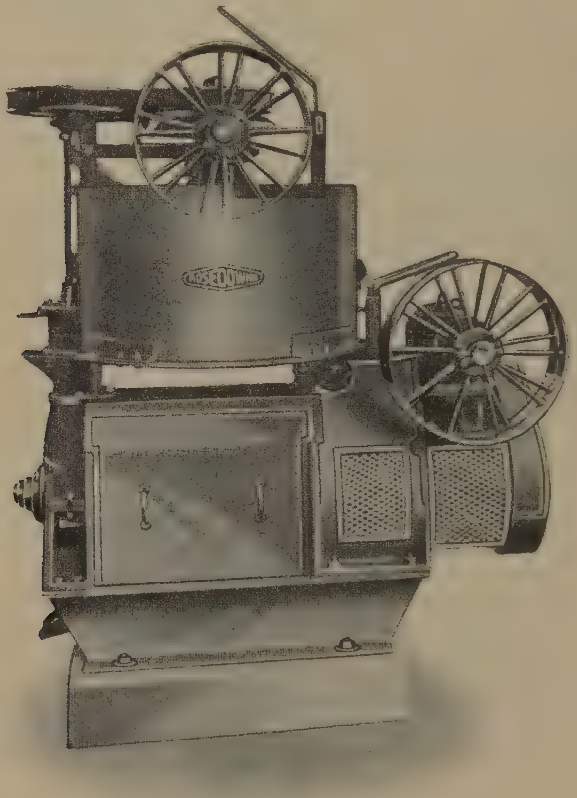

Figure V.

Oil Refinery.

If the oil is to be used for edible purposes, it would be necessary to refine it very thoroughly for it would contain impurities and free fatty acids which must be eliminated. The process would consist of three stages, neutralizing, bleaching, and finally deodorizing. The smallest oil refinery, specially adapted for the treatment of coco-nut oil, which is made by Rose, Downs and Thompson Limited, is quoted for below. This refinery has a capacity of 2½ tons per 24 hours.

The approximate freight weight of this plant is 33 tons, all pieces and packages being under 2 tons dead weight. The driving power required is 6–8 B.H.P.; the maximum steam consumption 800 lb. per hour at 100 lb. per square inch and the maximum water consumption 1,200 gallons per hour at 80° F. Figures VI. and VII. illustrate a small modern refinery.

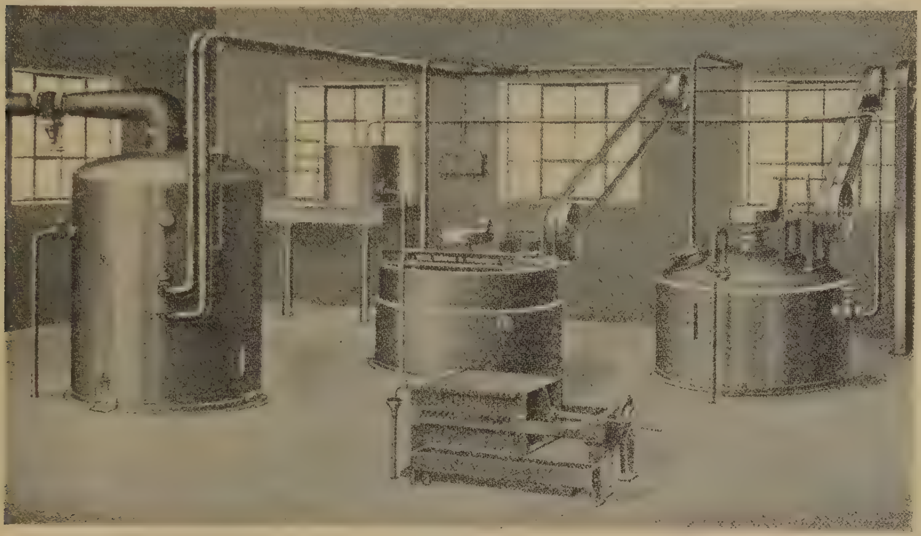

Figure VI.

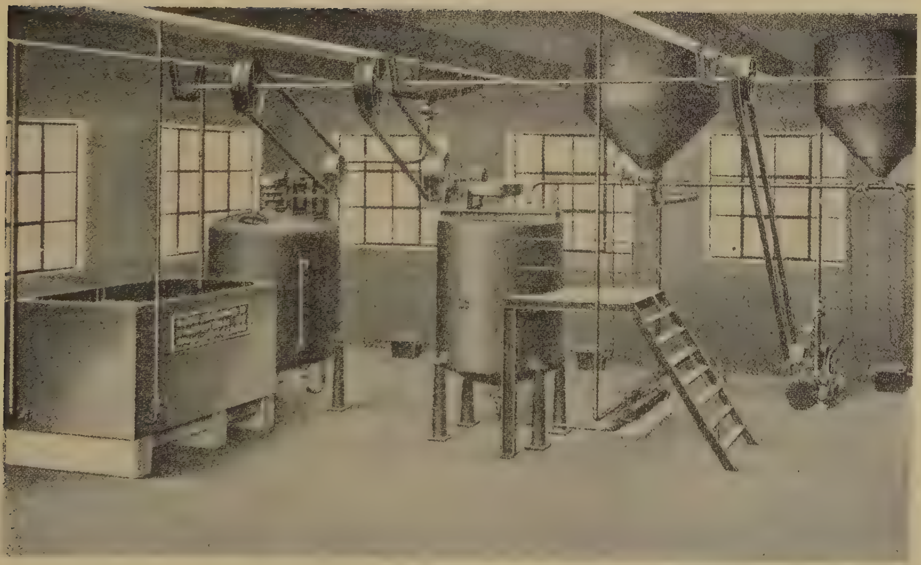

Figure VII.

Quotations.

The following quotations do not include power plant. The prices quoted are those which were current a few months ago, but the manufacturers reserve the right to charge prices ruling at the date of despatch.

ONE "ROSEDOWNS" N.P. SERIES "PREMIER" OIL MILLING INSTALLATION FOR THE TREATMENT OF DRIED COPRA, CAPACITY 6 TO 7 CWTS. PER HOUR WHEN PRESSING ONCE. SUITABLY EQUIPPED FOR SECOND PRESSING.

	£	*s.*	*d.*
One main feed elevator delivering to the disintegrator; for this and all other elevators in the mill we include chain, buckets, sprockets, &c., but exclude wooden trunking	38	0	0
One disintegrator with copra crusher feed, code word "Yerez", for the preliminary breaking down of the material, having a grinding chamber 17 inches diameter. To be equipped with screens of the most suitable size, and one spare set of beaters, and three spare sets of screens	76	0	0
One set of elevators, as described above, delivering from disintegrator to rolls	38	0	0
One set of five-high Anglo-American rolls, code word "Yefye", for the final grinding of the meal for the second pressing. The roller bodies to be of best chilled iron 12 inches diameter by 15 inches long, the rolls being suitably fluted. Complete with feed hopper, feed roll, driving gear, &c.	268	0	0
One set of elevators, as described above, delivering from the rolls to the kettle	38	0	0
One "Premier" pressing unit, code word "Ydune". To consist of—One seed heating kettle constructed of steel, internal dimensions 3 ft. 6 in. diameter by 34 feet deep, complete with steam and water fittings, stirrer, &c. This kettle to stand upon—One "Rosedowns" "Premier" cage press, having in the presshead our latest device for withdrawing charges of meal from the kettle, measuring same and delivering to the pressbox underneath. This pressbox or cage to be built up on our latest system of serrated steel staves held in position by massive steel rings, internal dimensions 18 inches diameter by 5 feet long. To have massive steel cylinder fitted with ram 14⅝ inches diameter and suitable for a working pressure of 3 tons per square inch. Complete with steel pressplates, hydraulic pressure gauge, steam traps to kettle, cover over cages, &c.	775	0	0
One set of hydraulic pressure pumps, code word "Yeiru", for serving the above press, having low-pressure pump 2¾ inches diameter, and two high-pressure pumps ⅞ inch diameter, all 4-in. stroke. To be equipped with supplementary cistern for holding the pressure fluid, and to be complete in respect with safety valves, driving gear, &c.	220	0	0
One hydraulic stop valve No. 161, to work in conjunction with the above press	25	0	0
One oil filter, code word "Yfsav", the filter having 24 chambers each 19 inches square, giving a total filtering area of 108 square feet. The filter to be constructed of our recessed plate type, each chamber being equipped with gunmetal outlet cock. The belt-driven pump to be complete with fast and loose pulleys, relief valve, pressure gauge, &c. The filter to be equipped with quick opening and closing gear; iron trough for filtered oil. The filter also to have two complete sets of filter cloths	142	0	0
One oil pump and cistern for collecting the filtered oil and delivering to storage	23	0	0
All the requisite gearing for the above installation, for transmitting power to the various machines, in accordance with plans that we would prepare, including polished steel shafting, pulleys, bearings, brackets, &c. (exclusive of driving belts which can be obtained locally). Including the oil piping connecting the press to the filter, but exclusive of steam piping	180	0	0
All the necessary spare parts and accessories for the above machinery, comprising pure woollen presscloth, repairing yarn for same, spare hydraulic leathers for press, pumps, and stop, &c.	88	0	0
	1,911	0	0
Packing and delivery f.o.b.	143	0	0
Total net price	2,054	0	0

One "Rosedowns" Oil Milling Installation for the Treatment of 5 to 6 cwts. per Hour of Dried Copra, First Pressing, but Equipped with Plant for Double Pressing.

	£	s.	d.
One main feed elevator delivering to the disintegrator. For this and all other elevators in the mill we include chain, buckets, sprockets, &c., but exclude wooden trunking	38	0	0
One disintegrator with copra crusher feed, code word "Yerez", as previously described	76	0	0
One set of elevators, as described above, delivering from the disintegrator to expeller for first pressing	38	0	0
One "Rosedowns" "Maxoil" continuous automatic oil expeller, belt-driven, code word "Exmax". This expeller to have a single kettle of our latest design, complete with compressing feed worm, speed reduction gear, automatic adjustment to cone, fast and loose pulleys, oil strainer in base, &c. ..	543	0	0
One steel settling tank with internal fittings for clarifying the oil	25	0	0
One oil filter, code word "Yfsav", as previously described	142	0	0
One oil pump and cistern for collecting the filtered oil and delivering to storage	23	0	0
One set of five-high Anglo-American rolls, code word "Yefye", as previously described for breaking down the first-pressing flakes	268	0	0
All the requisite gearing for the above installation, for transmitting power to the various machines, in accordance with plans that we would prepare, including polished steel shafting, pulleys, bearings, brackets, &c. (exclusive of driving belts which can be obtained locally). Including the oil piping from expeller to the filter, but excluding steam pipes from the boiler to the expeller kettle	172	0	0
An equipment of needful spare parts for the expeller, including pressure worms, pressure cone, packing worms, &c.	50	0	0
	1,375	0	0
Packing and delivery f.o.b.	103	0	0
	£1,478	0	0

One "Rosedowns" Oil Refining Plant with Deodorizing Apparatus for the Treatment of 2½ Tons of Coco-nut Oil per 24 Hours, Producing the Highest Grade of Edible Oil.

	£	s.	d.
One soda neutralizing tank, steam-jacketed, constructed of mild steel plates and arranged for mechanical agitation. Complete with control valves, gland cock and swivel for the oil, cock for the residue, &c.			
One caustic soda tank, constructed of cast iron, and fitted with outlet cock.			
One open top earth bleaching tank, constructed of mild steel plates and arranged with agitating gear. Complete with coil and control valve, outlet cock, &c.			
One filter press of the flush plate and distance frame pattern with drain tap on each plate. Complete with tray and set of cloths and cuffs.			
One steam-driven horizontal duplex pump for working in connexion with the filter press. Complete with usual equipment of lubricator, drain cocks, &c.			
One clean oil tank, constructed of mild steel plates and provided with coil and control valve. Tank knocked down for shipment to save freight.			
One steam-driven horizontal duplex pump for crude oil. Complete with usual equipment of lubricator, drain cocks, &c.			
One deodorizing vessel, constructed of mild steel plates and fitted with dry and perforated coils, control valves, vacuum gauge, thermometer, oil gauge fittings, &c. Vessel tinned all over internally with pure tin.			
One barometric condenser, constructed of cast iron, with domed top and coned bottom, and fitted with baffle plates. With suitable arrangements for vapour and water inlets and outlets.			
One vacuum cooling vessel, constructed of mild steel plates and provided with agitating gear. Fitted with coil and cold-water control valve, gland cock for oil outlet, vacuum gauge, thermometer, oil gauge fittings, &c. Vessel tinned all over internally with pure tin.			

£ s. d.

One oil-fired superheater for raising to the desired temperature the steam for the deodorizing vessel. Complete with burners, and all fittings, but exclusive of chimney.

One belt-driven dry vacuum pump for maintaining the desired vacuum on the deodorizing plant. Complete with fast and loose pulleys and belt-striking gear.

One oil barrelling tank, constructed of mild steel plates and provided with coil and control valves. Tank knocked down for shipment to save freight.

Pipes, valves, and fittings for the refining plant above specified, comprising steam, water, oil and other piping, but not including any mains to the plant or piping away from the plant.

Driving gear for the refining plant above specified, comprising the shafting, pulleys, pedestals, &c., but not including belting or motive power.

Total net price £1,709 0 0

R.C.H.

DRIVING POSTS OR PILING WITH DYNAMITE.*

On many occasions it is essential to put a piling or post in water or wet ground where a pile-driver is not available, particularly when just a few piling are to be driven, which would not warrant bringing in a heavy piece of equipment.

A method has been worked out whereby the force of dynamite can be used to transmit a blow which is somewhat similar to the dropping of a pile-driver hammer. The pile is stood upright in the location desired, and braced in place—usually with rope. The head of the pile should be sawed off square, and the procedure is to put a heavy plate of steel on top of the pile. To give the best results, the plate should be 1 inch to 1½ inches thick. One stick of dynamite is placed on top of the plate, and covered with mud, after the stick has been properly primed with a blasting cap and fuse or an electric blasting cap. When the charge is exploded the force is transmitted to the plate, which in turn transmits it to the pile. The pile is driven into the ground sometimes as much as 14 inches, if the ground is soft. The procedure is then repeated until 1 inch penetration per explosion is obtained.

If the top of the pile is not square, or if there are some flaws in the wood near the top, a brooming or split effect usually takes place. Hence it is advisable to have about 4 feet extra length, which can be sawed off after complete penetration is obtained.

While this procedure is not an economical one, provided a pile-driver is available, it does provide a new method for putting individual piles or heavy posts in the ground in a very solid compact manner.

The Engineering Division of the United States Forest Service completed some comparative tests between dynamite and a pile-driver for this work.

Piles of a standard size were put down with dynamite shots until the penetration was equal.

Various loads of dynamite were used and results indicated that in general one stick of 50 per cent. Straight N.G. Dynamite weighing ½ lb. was the maximum load to use.

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* Reprinted from *Agricultural News Letter,* Vol. 8, No. 3, p. 47.

THE PACKING AND KEEPING QUALITIES of DESICCATED COCO-NUT.*

By Dr. Reginald Child, B.Sc., Ph.D., F.I.C.

1. Moisture.

The keeping qualities of desiccated coco-nut, like those of copra, depend almost entirely upon its moisture content. In the presence of more than a minimal amount of moisture, both desiccated coco-nut and copra become a prey to the attack of moulds, increasing in severity with increase of moisture content.

It is possible to illustrate this by an actual test carried out by the writer. Samples of desiccated coco-nut of different moisture content were kept for two months in sealed containers, after which they were opened and examined:—

Original Moisture Content.	Appearance after two months.
1.8	White, free from mould. Odour good
3.65	Fair
4.73	Traces of mould growth. Odour distinctly rancid
6.73	Considerable growth of green, pink and brown coloured moulds. Odour strongly rancid

Desiccated coco-nut exposed freely to the air even if well dried initially will, under Ceylon conditions of humidity, absorb fairly rapidly up to 6 per cent. of moisture. It is clear therefore that:—

(*a*) The initial moisture content must be low, certainly below 3 per cent.
(*b*) Packing must be such as to prevent absorption of moisture from the air.

2. Packing.

Desiccated coco-nut is exported usually in plywood chests holding 130 lb. The chests are lined with suitable paper or other material (see below). The desiccated coco-nut is sometimes packed with light baling pressure. Although this packing in chests is not a fundamentally water-proof one, in practice, the small surface actually exposed to the air makes it satisfactory enough if condition (*a*) is observed, i.e., the initial moisture content is low. Cases found spoiled by mould action on arrival at overseas destinations are, in the writer's opinion, more often the result of packing originally imperfectly dried material, than of moisture absorption in transit.

Cases have occurred, however, where locally made chests were employed made of improperly seasoned wood. The contents of the chest absorbed moisture from the damp wood and spoilage rapidly set in. The way to prevent this type of spoilage is obvious.

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* Reprinted from "Coconut Industries," Vol. 4, No. 1, p. 9.

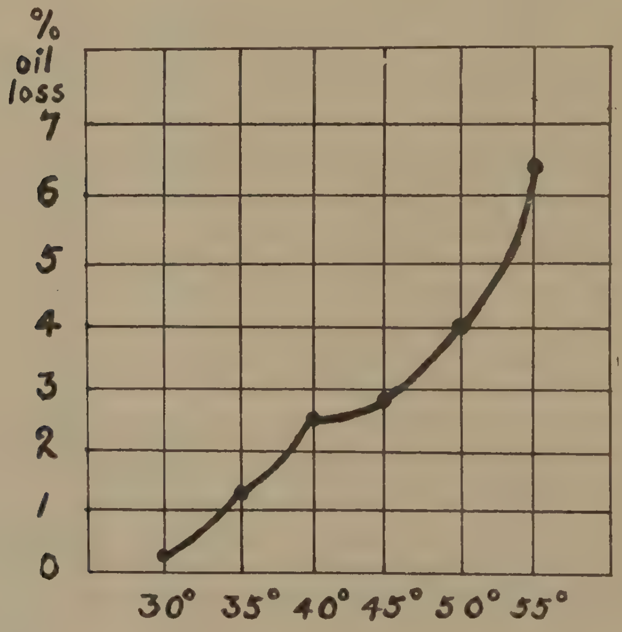
Linings.

For lining desiccated coco-nut chests, a grease-proof paper is commonly used. In general, it may be supposed that materials found satisfactory for lining tea-chests will serve well for desiccated coco-nut. There is however this difference, that desiccated coco-nut contains over 70 per cent. of oil, and that this may adversely effect certain lining materials. Hence the use of grease-proof paper, usually of the kraft type.

3. Case Staining.

At moderately high temperatures desiccated coco-nut loses oil, causing "case-staining". This is objectionable from the point of view of appearance but also because such oil acts as a focus of rancidity as it is exposed to the oxidative influence of light and air. (*See* below, paragraph 4). Loss of oil does not commence to be serious below 90° F., but above this temperature becomes increasingly severe with further rise. The following table shows the percentage of oil lost at different temperatures, based on even tests:—

	°C.	°F.	Loss.
Temperature	30° =	86° —	Very small
"	35° =	95° —	1.5%
"	40° =	104° —	2.6%
"	45° =	113° —	2.8%
"	50° =	122° —	4.0%
"	55° =	131° —	6.2%



During shipment to the United Kingdom temperatures of above 90° F. for some days may be experienced, particularly in the Red Sea. But the problem becomes more serious in the climate of parts of India, and needs particular attention when attempts are being made to foster sales of desiccated coco-nut in that country.

Consequently, trials have been carried out of packing in tins. These are mentioned in paragraph 5.

4. Other Types of Spoilage.

Before discussing packing materials further, it will be as well to describe briefly the types of spoilage to which desiccated coco-nut is liable. It was mentioned in paragraph 1 that excessive moisture was a prime factor in deterioration. Desiccated coco-nut containing fat, sugars, protein and mineral salts is an excellent medium for growth of moulds, yeasts and bacteria, if moisture is present.

By reason of its high fat content (over 70 per cent.), desiccated coco-nut is chiefly liable to deterioration related to this fat as opposed, say, to meat, where spoilage is primarily due to bacterial decomposition of the proteins. Even if kept satisfactorily dry and free from the action of micro-organisms, it is therefore liable to rancidity (using this word in its widest general sense) due to atmospheric oxidation. Such spoilage may be roughly described as "ageing."

Factors which increase the rapidity of this type of deterioration are air, light and heat. Traces of certain metallic impurities such as copper and iron also accelerate oxidation, but these are not usually serious in the case of desiccated coco-nut.

Exclusion of air by the use of air-tight as well as water-tight packing is therefore advantageous.

Action of Heat.

The rate of oxidation of fatty substances increases rapidly with rise of temperature, and so high temperatures are to be avoided if possible for this reason as well as for the reasons given in paragraph 3. Desiccated coco-nut should be stored under as cool conditions as possible.

Action of Light.

Exposure to light has a marked effect in accelerating the development of rancidity. This is of no account in the case of bulk transport, but becomes of considerable importance in packing for retail use.

The effect of light may obviously be eliminated by the use of opaque wrappers such as metallic foil. For attractive appearance it is often desired to use transparent or semi-transparent wrapping.

It is found that the most active wave-lengths of light are the shorter rays—blue, violet and ultra violet—so a wrapper excluding these is desirable. A coloured cellophane or paper meets the case—yellow, red or brown.

It may be added that there is no advantage in using coloured paper or wrapping in containers that are already perfectly opaque.

5. Examination of Old Samples.

The statement in the previous paragraph that the spoilage of desiccated coco-nut is largely related to its high fat content may be illustrated by the results of the examination of two samples in 1906, which had remained until 1935 in the Economic Museum, Peradeniya, and were sent to the writer by the courtesy of the Economic Botanist. These were analysed in 1935 and again in 1938.

—	Fresh D.C.N. Typical Analysis.	1906 Sample Fine.		1906 Sample Coarse.	
		1935.	1938.	1935.	1938.
Moisture	1.5	13.9	49.2	11.6	13.5
Oil	69.5	32.3	19.6	39.1	40.2
Oil (dry weight)	70.6	37.5	38.6	43.7	46.4
Oil—					
F.f.a.	0.02	44.7	..	45.7	..
R.M. Value	7.8	..	..	..	4.1
Polenske Value	..	..	..	..	13.9
Dry Poonac—					
Mineral matter	5.4	..	6.3	5.0	5.2
Nitrogen	3.7	3.8	3.8	4.0	4.0
Crude fibre	9.2	8.5	..	..	..
Cellulose	..	..	..	..	30.8

These samples had been kept in bottles freely exposed to the light. They were dark brown in colour and of bad odour, but the deterioration was more of the type due to ageing than to moulds. As the analytical figures show, the oil content was about half normal, and the oil was extremely acid. That is, half the oil had been completely destroyed by oxidation, and the remainder consisted half of free fatty acid. The poonac remaining after the oil extraction gave, however, fairly normal values for nitrogen (protein), cellulose fibre and mineral matter, so these latter had not undergone drastic changes in 30 years.

6. Absorption of Taints.

Desiccated coco-nut, like most edible products of high fat content, readily picks up taints from odours given off in its vicinity. Packing cases made of unsuitable varieties of timber, particularly those of strong resinous odour, are very liable to impart undesirable flavour. Metallic foil, e.g., aluminium, is the best impervious wrapping to keep out undesirable odour. Grease-proof and waxed papers are often inefficient.

7. Small Wholesale and Retail Packing.

(*a*) Packing in Tins.

Packing in sealed tins should be satisfactory from all points of view: prevention of moisture absorption, exclusion of light and air, and prevention of tainting.

The desiccated coco-nut must be packed dry at a moisture content below 3 per cent., and preferably even lower than 2 per cent. Two tins of a proprietary brand packed in England were recently examined by the writer; the time since packing was not known but was probably considerable. The contents were brown tinged and slightly rancid in taste and odour; the oil expressed was acid (f.f.a. 1 per cent. as lauric), moisture contents 3.3 and 4.4 respectively.

Tins to contain 28 lb. have dimensions 7⅞ inches by 11⅜ inches by 17⅞ inches (i.e., internal volume about 1,500 cubic inches). They are lined with grease-proof paper, the desiccated coco-nut is weighed in, and the lids (of the press in type) are fitted and soldered. The desiccated coco-nut must not be packed hot.

This type of packing might suit the Indian market. The tins have resale value, which meets the objection that the value of a tin is almost equal to that of its contents—28 lb. of desiccated coco-nut. However, trade opinion does not seem altogether favorable.

(*b*) Retail Packing.

Putting up desiccated coco-nut in retail packages of 4 oz. or ½ lb. or so is a somewhat tricky business, especially for tropical climates. Small packets become spoiled with amazing rapidity in unsatisfactory wrappings. It may be said at once that cellophane (of the old type) or grease-proof paper packets are not satisfactory.

One small packet was kept for six weeks before analysis. At the end of this time the sample was mouldy and quite rancid and unfit for use. Moisture content was 13.6 per cent. and f.f.a. of extracted oil 6.6 per cent.

Considerable success has been attained by the use of lead or aluminium foil. Well prepared packets wrapped in aluminium foil are satisfactory. The foil excludes vapours, causing taints, light and moisture.

Transparent wrappings are sometimes desired. In this case red, yellow or brown are to be preferred. Most papers and ordinary cellophane are, however, by no means waterproof. A moisture-proof cellophane is marketed.

A new transparent material of considerable interest is Pliofilm.

Pliofilm is a rubber hydrochloride; it is a material of a similar appearance to cellophane and is used in the manufacture of raincoats, umbrellas, packing material for perishable goods, oil cartons, and ribbons for florists and speciality stores. It is claimed that Pliofilm has properties such as resistance to moisture, elasticity, strength and an attractive appearance surpassing those of other material.—(The *R.R.I. Planters' Bulletin*, No. 8, 1939.) The mechanical, physical and chemical properties of the material are described in *India Rubber World*, 1938, 98, No. 3, pp. 46-47.

Tea Packing.—The Tea Research Institute found Pliofilm very satisfactory for tea packing, even the thinner grades being sufficiently strong for the purpose of lining tea chests. At the time of their tests in 1937, the cost of the thin grades was about equal to that of the normal aluminium foil.

The writer has carried out a preliminary test on 4-oz. packets of desiccated coco-nut in Pliofilm. The desiccated coco-nut was in good condition after nine weeks.

Pliofilm is definitely waterproof and has the advantage of being readily heat-sealed.

(*c*) Effect of Oil on Wrappings.

In paragraph 2, reference was made to this. Pliofilm underwent no apparent change after complete immersion for ten days in coco-nut oil.

(*d*) Labelling Packets.

Difficulty is sometimes experienced in attaching labels to aluminium foil packets, the usual gums not adhering well to the metal surface. The following formula for an adhesive has been found very useful in actual practice:—

	Grams.
Dextrin ("British Gum"), soluble variety	64
Sodium silicate (water glass)	16
Glucose	8
Water	100
	188

8. Preservatives.

Desiccated coco-nut, properly dried and packed, should not require the addition of preservatives, and such additions would generally be undesirable. The use of sulphur dioxide has been tried, but this is not a particularly useful preservative for fats and fatty substances.

9. Analysis of Desiccated Coco-nut and Detection of Spoilage.

Good desiccated coco-nut should be of pure white colour, crisp, and with a fresh taste of the nut. It should contain 68.72 per cent. of oil, and the free fatty acid of the oil should be below 0.1 per cent.

Although acidity of the oil is not the same thing as rancidity, it goes more or less parallel with rancidity in the early stages and the free fatty acid of the oil is a useful indication when taste, odour and appearance are also taken into account.

Oil Content.

Since one of the troubles experienced with desiccated coco-nut packing in hot climates is "Case Staining" (see paragraph 3), a suggestion for preventing this might be deliberately to reduce the oil content by gentle expression to provide a "tropical DCN" of lower oil content than the usual 68–72 per cent.

10. Conclusion.

The writer will be very glad to receive any comments on the foregoing memorandum, especially from those concerned in the desiccated coco-nut industry. Reports of actual experience will be especially welcome.

PRESERVATION OF FISH IN WARM CLIMATES.*

The principal methods of preserving fish, other than canning, are refrigeration, salting, smoking and drying. The details of the methods used vary in different countries according to local conditions and requirements.

Refrigeration.

To produce frozen fish which after several months of storage is equal in flavour and food value to freshly caught fish, it is essential that they should be placed in the freezing room as soon as possible after leaving the water. Bruising or damage hastens their deterioration, and they should, therefore, be handled as little as possible. A difficulty in freezing fish in tropical countries is that any very slight increase in temperature causes changes in the flesh which cannot be remedied by freezing. Freezing only keeps the fish in the same condition as that in which it entered the refrigeration chamber, and it is therefore essential that it should be in prime condition. Unless fish can be delivered to the chamber within three or four hours after landing they should be kept in ice or under refrigeration in the boats.

Before freezing, all fish should be thoroughly freed from dirt and slime in clean, cold, running water. Either fresh water or sea water may be used, but care should be taken that it is pure. Larger fish are usually " gutted " before being frozen, although practice in this respect depends on the market for which they are intended. Gutting of smaller fish is normally impracticable. Fish containing much oil are apt to deteriorate more quickly than other varieties.

For freezing, the fish are commonly placed in pans which are set on the refrigerating pipes until the fish are frozen. They are removed by pouring a little cold water on the outside of the pan, which causes sufficient melting to allow the frozen fish to be removed from the pan. Where it is desired to freeze each fish separately, they may be placed on trays or shelves over the pipes.

In most modern up-to-date plants the fish are quick-frozen in brine, and this method is stated to give a product superior to that obtained by freezing in air.

After freezing the fish are " glazed ". Glazing is designed to encase each fish in a protective coating of thin clear ice which prevents the evaporation of water from the flesh of the fish with consequent shrivelling, helps to prevent the fish turning white, and prevents the entrance of air which tends to make the fish oils deteriorate. Glazing also provides an ice surface on which moulds and fungi cannot grow.

For glazing the fish are immersed quickly in a trough of clean fresh water at a temperature just above freezing point, in a room in which the temperature is maintained at 20° F. to 25° F. The water covers the fish with a thin film, which freezes instantly into a thin coating of ice as soon as the fish is withdrawn from the water. The fish are immersed three or four times until the coating of ice is considered sufficient, and every part of the fish is covered.

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* Reprinted from *Bulletin of the Imperial Institute*, Vol. 27, No. 4, p. 561.

Another method of glazing is by means of a hose with a special spray nozzle with which a fine stream of water may be sprayed on the frozen fish.

After glazing the fish are taken to the cold-storage rooms, which are kept at temperatures ranging from − 5° to + 10° F., and kept until required for market.

Salting.

Difficulties in salting fish in warm climates are due chiefly to the slow penetration of salt and the rapid decomposition of the fish. In this connexion, in experiments carried out in the Fishery Products Laboratory, United States Bureau of Fisheries, it was found that calcium and magnesium salts, common impurities found in commercial salt, greatly retard the penetration of the salt into the fish. It was also found that the salt penetrates the fish far more quickly if it is applied as dry salt than if in the form of brine. Of great importance also in the salting of fish in warm climates, is the thorough cleaning of the fish before salting, since it was found that while thoroughly cleaned fish could be salted successfully at temperatures of 90° F. to 100° F., fish containing blood, roe and milt spoiled at about 65° F.

Before salt is applied, therefore, the fish should be beheaded, and the entrails, kidneys and roe removed, and the fish thoroughly washed, preferably in cold brine about the strength of sea water, or in fresh water. The fish should be rolled in the salt, which should be as fine grained as possible, the belly cavities filled, and the fish packed with their backs down, in tubs. A weight should be placed on the fish, sufficient to keep them immersed in the brine formed by the absorption of the water from the fish by the salt without crushing them. After the fish have become thoroughly saturated with salt, or "struck through," the tubs may be packed full.

Another method of salting which is also used is that of brine salting. In this method the cleaned fish are placed in large vats partially filled with concentrated salt solution. A small amount of salt is put on top of the fish floating in the brine, and the fish are stirred regularly to prevent the brine becoming too dilute at any one point.

The proportion of salt used varies from 10 per cent. to 35 per cent. of the weight of the fish, according to the kind of fish, climatic conditions and local customs. The time required for salting depends on the temperature and the size of the fish. Small fish can often be salted in about two days.

For immediate marketing the fish should be taken from the brine and the brine drained off. More dry salt is then applied, and the fish are packed in containers ready for the market. If the fish are to be held for some time, however, it is necessary to keep them under the brine continually to exclude air, which causes the fat in the fish to "rust". For this purpose the barrels should be filled with fish, headed, and nearly filled with brine through the bunghole. In warm climates, however, where possible, salted fish which is not to be consumed for any considerable time should preferably be kept in cold storage.

In connexion with the salting of fatty fish, experiments carried out at the United States Bureau of Fisheries Laboratory in 1937 showed that the addition of 30 per cent. of pulverized whole oats, based on the weight of salt used, to the brine in which mackerel were first dipped for salting, considerably reduced rancidity in the fish after storage. As far as the Imperial Institute is aware, however, this process if not being used at present on any commercial scale for the salting of fatty fish.

Another method of preserving fish, which is closely related to salting, is the preservation by means of sodium hypochlorite, which is a powerful preservative and sterilizer, and, in acting on organic matter, is converted into sodium chloride. The Madras Fisheries Department have been making preliminary experiments with this method, but it is not used to any commercial scale at present.

Smoking.

Small fish are usually smoked without evisceration: larger fish are beheaded, eviscerated and cut into strips or small pieces. In Europe and America fish are generally salted by immersion in brine or by adding dry salt before smoking, the degree of salting depending on the nature of the fish and the type of product desired. In the East, fish are often smoked without any preliminary salting. Before smoking and after immersion in brine the fish should be partially dried in the open air.

Smoking is of two kinds, hot-smoking and cold-smoking. In hot-smoking the fish are kept close to the fire and are wholly or partly cooked in the smoking process, which is completed in a few hours. In cold-smoking the fish are hung some distance from the fire and are smoked at a temperature not exceeding 80° F. The time taken for cold-smoking varies, according to the product required, from a few hours to several weeks, as in the case of hard herring.

The woods chiefly used for smoking are hard woods, the most important consideration in choosing the woods being to use one which burns slowly and produces a large amount of smoke. Soft woods which contain resin should not be used, since the resins are liable to give a disagreeable taste to the fish.

The method of building the fire and the erection of the smokeroom depend considerably on the capital available and the quantities of fish to be smoked. For smoking small quantities of fish, a barrel with the lower end of one or two staves removed, is placed on the ground over a small pit, in which the fire is made. The fish for smoking are hung from rods supported at the top of the barrel, and the barrel is then covered with sacking or coarsely woven cloth to keep the smoke in. Fuel may be placed on the fire through the holes made in the barrel by the removal of the staves. In China long narrow furnaces about 3 feet high and 3 feet wide are constructed of stone or concrete, with holes in the top. The smoke from the fire passes through the holes to the fish, which are contained in baskets.

Drying.

Drying preserves fish by destroying enzymes and removing water which is necessary for bacterial growth. Fish having a fat content of over 0.2 per cent., however, is not suitable for dehydration by ordinary processes since on storage of the fish the oil contained in it becomes rancid.

Methods of drying fish differ according to the locality. The main principles consist, however, of washing and eviscerating the fish and then drying them, usually in the sun, although where suitable plant is available, they may be dried in moving air currents or *in vacuo*. The more rapidly the fish are dried, the more rapidly they may be re-hydrated when required for use. In some districts the fish are salted or boiled for a short time before being dried. When unfavorable weather conditions are likely to make drying difficult and prolonged, preliminary salting is probably advisable. For drying, the fish may be hung on poles or placed on mats in the sun.

Although dehydration of fish helps to prevent autolytic changes and bacterial growth, it does not prevent oxidation of the fat in the fish. Dried fish should, therefore, be stored away from sunlight and warm air. Storage *in vacuo* or in inert gas such as carbon dioxide is preferable, where possible, although where the fish is for fairly immediate consumption such precautions need not be taken.

Dried fish normally weighs only about one-tenth of its weight when fresh, and in this form it can be economically stored and transported.

A NEW FLY SPRAY.*

Science News Letter, 16th December, 1939, p. 392, under title "New Family of Chemicals Parade at New York Show", states: "Any new use for castor oil to divert it from the use that you think of when you hear the name is news. Castor oil is being used to make paint, replacing tung oil largely imported from China and now difficult to get on account of the Japanese invasion."

To this important new use for castor oil may be added another valuable discovery involving the use of castor oil. Large quantities of pyrethrum obtained from a species of chrysanthemum plant are used in suitable hydrocarbon oil bases as fly sprays. The most important of the chief sources of pyrethrum is Japan, and, as in the case of tung oil, the supply is adversely influenced by the war. Castor oil again comes to the rescue.

Castor oil, when subjected to heat, is broken down into undecylenic acid, heptaldehyde and residues. The undecylenic acid is separated by distillation and treated with isobutylamine to form isobutyl undecylenamide. This, when used in combination with small amounts of pyrethrum in a suitable base oil, is an excellent spray for flies, better than either pyrethrum alone in the base oil, or isobutyl undecylenamide alone. Synergism appears to be demonstrated by the mixture. The isobutyl undecylenamide replaces about two-thirds of the pyrethrum formerly used and represents about ½ per cent. in the spray. In addition to the superior killing properties of the mixture, the castor oil derivative has the advantage of being a stable compound that can be manufactured according to specification. This is in contrast to pyrethrum, which is unstable and uncertain as to quality and supply. Extensive commercial use has proved the high efficiency of this fly spray, which was previously shown experimentally.

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THE CULTIVATION OF NATIVE FOOD CROPS.

(Continued.)

By E. C. Green, A.I.C.T.A. (Trin.), H.D.A.
Demonstration Plantation, Keravat.

4. Cassava.

Cassava, or tapioca, is a root crop which is grown throughout the tropics, it being grown for food and sale to other countries. Cassava tubers contain poison which is rendered inert by cooking, drying in the sun or peeling and scraping the tubers and washing them many times in water.

Cassava has many uses; the tuber can be removed from the ground, peeled and boiled or roasted for food, or it can be dried and made into flour, or the starch can be removed and used in washing clothes. The tubers of cassava also produce raw material for the manufacture of power alcohol.

There are many varieties of cassava in cultivation and, for food purposes, those containing the least amount of poison are best.

Climate.—A warm, moist, tropical climate is ideal for cassava.

Soil.—Cassava will grow in most types of soil, but wet soils are no good as the tubers rot in the ground before they have matured or grown to any size. The best soil for cassava is one that is not too heavy, well drained, and contains a lot of organic matter.

Preparation of Land.—Land that is to be planted with cassava must be hoed to a depth of at least 9 inches in order that the tubers will have loose soil in which to develop.

There are four methods of planting—

1. Hills.
2. Ridges.
3. Furrows.
4. Erect in ground.

1. When planting in hills it is customary to make the hills about 4 feet apart, 1 foot to 1 ft. 6 in. high and flat on top. Two cuttings are planted in each hill.

2. When planting in ridges, the land is prepared in a similar manner to yam ridges, only the ridges are spaced 4 feet apart and each cutting is planted at 4 feet intervals along the top of the ridge, which has been previously flattened in the same manner as the hills.

3. The furrow method is used a great deal—furrows, resembling shallow drains, are made 4–6 inches wide, 4–6 inches deep, 4 feet apart, and each cutting is put in the bottom of the furrow at a spacing of 3 to 5 feet depending on the richness of the soil.

4. The method of planting erect in the ground without hills or ridges is commonly used by native cultivators in this Territory, and should only be used in very loose, well-drained soils. For this method two holes about 4–6 inches deep are made side by side and one cutting placed in each at an angle of about 45°.

The holes are lined 4 feet apart in rows and spaced 3–5 feet apart in the lines.

Planting Material.—Short lengths of stem known as cuttings are used as planting material. Native cultivators generally make their cuttings about 18 inches long, but such long cuttings are not necessary and are a waste of good planting material. The bottom sections of the stem make the best cuttings, but the middle sections of the stem, i.e., from about 3 ft. 6 in. to 5 feet from the ground are quite suitable. The extreme ends of the stems should not be used. The cuttings are made about 6 inches long, and when planting it is essential that they are not planted upside down in the soil, and also that the end of the cutting for a distance of 1–2 inches is out of the ground.

After Cultivation.—Weeds must be controlled until the crop has grown enough to shade the ground and keep the grass from growing.

If methods 3 or 4 have been used, a commencement must be made to hill the crop when the plants are about 3 ft. 6 in. to 4 feet high. Hilling is carried out gradually during the first few months, after which time it should not be necessary to hill up any more. Where ridges or hills have been used these must be reformed from time to time if flattened by heavy rain. Once the tubers have commenced to form, the soil around the base of the plants should be disturbed as little as possible, otherwise the tubers may be damaged.

Harvesting.—Cassava matures in about nine to twelve months after planting but in well-drained soil, or if the weather is not too wet, the crop can remain for a long time in the ground without much damage.

The period of maturity is usually shown when the plants have flowered and formed seed, but as this is not always a sure indication, it is advisable carefully to remove the soil from a number of plants and inspect the tubers to see if they are fully developed.

Cassava is harvested by hand, the soil is removed from the base of the plant and the tubers are cut off from the stem and carefully taken out of the ground. Cassava will not keep very long once it is harvested, and for this reason, it is advisable that only sufficient for one day should be removed each time.

Treatment of Land after Harvest.—Cassava takes a lot of food out of the soil, therefore, two crops in succession should not be grown in the same piece of land. After harvesting, remove and destroy the stems, after any planting material that is needed has been obtained, then hoe up the land and plant cowpea or some other legume.

Preparation for Food.—Cassava can be boiled or roasted when freshly harvested or dried and made into flour or meal.

To make flour, first wash the tubers, peel them and then grate them (a suitable home grater can be made by punching nail holes in a piece of galvanized iron). After grating the material is washed with water and then dried, or it can be squeezed through a piece of cloth into a tin, allowed to sink to the bottom of the tin after which the water is poured off and the white material left is placed in the sun to dry. In this second method the flour is very fine and looks like powder as all the fibre has been removed and only the starch remains. In the first method, a coarse flour is obtained. To make cassava meal, first wash and peel the tubers, then cut them into small circles like pennies or in thin strips like wood shavings, and dry in the sun. When thoroughly dry these cassava "chips", as they are called, can be pounded up finely, mixed with water to make a "dough" as in breadmaking and then cooked. The fine flour which is made when the cassava is scraped and squeezed through a cloth can be used for starching clothes.

5. Maize or Corn.

Maize is one of the best grain crops that can be grown for food. In the immature state the cob can be boiled or roasted and the grain eaten, whilst when mature and dry the grain is removed from the cob, finely ground in a machine, and made into cakes or porridge. Maize requires a well-drained soil fairly rich in plant food, and it does not like too much rain especially when the cobs are ripening.

Maize is planted in rows spaced 3 feet apart, and the seed is sown 2 feet apart in the rows, about 2–3 inches deep with two or three seeds at each place. The correct time of the year to plant will depend on the period when the most rain occurs. Always try to plant so that the crop will not mature during the wet months, also, if the seed is planted at this time, the crop might fail due to the seed becoming rotten in the ground before it germinates.

Germination occurs very quickly after planting and in 4–5 days the young shoot should be seen above ground. Once germination takes place the plants grow quickly and reach a height of up to 8 feet or more in about six to seven weeks. Tasseling or flowering occurs six to seven weeks after planting and in ten to eleven weeks the cobs should be ready for boiling or roasting. The crop matures in thirteen to fourteen weeks, and the cobs are removed from the stalk and hung in a barn or shed until thoroughly dry.

Whilst the crop is growing all grass and weed growth must be kept under control, and this is best done by means of a hoe.

When selecting seed maize for planting, always discard the seeds from both ends of the cob, and only use the central grains. Select large cobs with straight even rows containing grain that is well filled. Seed planted from cobs that are undersized, or not properly filled with grain, or where the grain is uneven in shape, or where the rows are not straight, will produce a large percentage of cobs which resemble the unsuitable cob from which the grain was taken.

6. Rice.

In the tropics rice is the most important grain food for native races. There are two types of rice cultivated—

1. Swamp or wet rice.
2. Upland or dry rice.

SWAMP RICE.

Soil, &c.—Swamp rice needs a soil rich in humus and fairly heavy, the ideal soil being one containing a fair amount of sand and humus with a heavy type of sub-soil. In a soil of this sort, the roots of the rice can easily grow through the fairly light upper soil and the heavy lower soil stops the water from draining away.

The climate for swamp rice must be hot and rice likes plenty of sunlight.

Preparation of land.—In most parts where swamp rice is grown irrigation is practised. The land is levelled into small plots and surrounded by banks 1 ft. 6 in. to 2 feet high, and at intervals along the banks openings are made so that water can be run on to the land or run off it, whichever is necessary. On sloping land terraces are made, divided into compartments by means of earth walls, and openings made in the lower walls so that the water may run from the top compartments to the lower ones.

Once the land has been levelled it is dug up, flooded with water and "puddled" i.e., trampled until the surface is thick mud.

Planting.—After the land has been prepared the ripe seed is soaked in water for 24–48 hours then planted in one corner of the field or in a specially prepared nursery a short distance away.

When the young rice plants are about 6 inches high they are taken out and planted in the field about 6-9 inches apart, either singly or two or three plants together.

Some rice cultivators plant the seed thickly direct into the field and thin out the plants later, the plants taken out being planted in the patches where the seed has not properly germinated.

It is generally considered, however, that the nursery method is best and more rice is produced.

After cultivation.—The fields must be kept clean of weeds, and as the rice is so closely planted these must be removed by hand which is a tedious job, all the weeds after removal being buried in the mud to enrich the soil. The fields are kept flooded with water to a depth of 4-6 inches until the rice commences to flower, when the depth of water is gradually reduced until the land is only just moist at harvest time.

Harvesting.—The period of maturity depends on the variety that is grown and is from five to nine months. When the heads containing the grain are a golden yellow, it is time to harvest and the heads, with about 6-9 inches of stalk attached, are cut off.

The heads are now made into small bundles and dried in the sun or hung up in an open, well-aired shed.

After drying, the grain is removed by beating the heads on a piece of timber about 1 foot in diameter, or on a pole fastened about 1 ft. 6 in. to 2 feet above the ground. Trampling over the rice on a hard floor will also remove the grain from the heads. The grain after its removal from the head is known as "Padi".

Upland Rice or Dry Rice Cultivation.

Soil.—Upland rice needs a good well-drained soil containing a fairly large amount of humus. The climate best suited to its cultivation is one in which not much rain falls during the ripening period.

Preparation of the Land.—The land should be dug up or hoed as deeply as possible and all green material turned into the soil.

Planting.—Two or three seeds are planted in rows 1 foot to 1 ft. 6 in. apart and at intervals of 1 foot apart in the rows. It is important that too many seeds are not planted at each place, otherwise the rice "clumps" become too thick and not a great deal of grain is formed.

After Cultivation.—The rice seeds germinate quickly and shorty after planting are 4-6 inches high. Weed and grass growth must be controlled until the plants have made so much growth that it is hard to work in the crop without damaging it.

Harvesting.—The period of maturity varies from about four and a half months to seven months, according to the variety; the one at Keravat known as "Santap pangkur", matures in about five to five and a half months.

Upland rice is harvested, bundled, dried and the grain removed from the heads in the same manner as for swamp rice.

Treatment of "Padi" for eating.—The rice grains after threshing have a covering called the "husk" and before cooking it is necessary to remove this husk, which is accomplished by means of a machine or a pestle and mortar.

The native method of removing the husk is with a pestle and mortar. The pestle consists of a round hardwood stick about 5-6 feet long and 3 inches in diameter, with one end slightly sharpened.

The mortar consists of a hole that has been made in a block of hardwood, the hole is about 1 foot in diameter at the top, 9 inches deep and slopes down to about 3 inches diameter at the bottom. The "padi" is placed in the mortar and pounded with the pestle until the husk is removed after which it is winnowed by pouring from some container placed about 10–15 feet high on to a bag or mat on the ground. As the husked "padi" passes through the air the heavy rice grains fall on to the bag and the light husks and flour are blown away by the wind.

7. Groundnuts or Peanuts.

The groundnut or peanut is a valuable food and contains a high percentage of oil; it is also a legume, and improves the fertility of the soil.

It is a small, annual plant which grows to a height of 1-2 feet, some varieties are bunch types, that is, they grow erect whilst others are the "runner type", that is, the stems trail along the ground.

Peanuts require a loose open type of soil containing a fair amount of lime, warm weather conditions, and not too much rain.

There are two methods of planting peanuts—

1. In ridges.
2. On the flat.

Where there is a possibility of a heavy rainfall it is advisable to plant in ridges, the ridges being made about 1 foot high and spaced 2 feet to 2 ft. 6 in. apart.

Where the rainfall is not too heavy peanuts are planted on the flat, the rows being spaced 2 feet to 2 ft. 6 in. apart according to the variety. "Runner types" are planted further apart than "bunch" types.

Before planting, the seed is removed from the shell, and one or two seeds are planted at intervals of 1 foot to 1 ft. 6 in. apart along the tops of the ridges or in the rows.

The seed germinates quickly and should be showing above the ground in less than a week.

As the crop grows, it must be continually "hilled", that is, the ground is pulled up around the plant by means of a hoe or some other suitable implement. The reason for hilling is that from each "node" along the stem a long "spike" grows downwards towards the soil, and some of the nuts are formed on the end of it.

The crop is ready to harvest about 3-4 months after planting, and the period of maturity is when the old leaves have fallen off and the younger leaves are covered with brown spots.

At harvest the whole plant is pulled out of the ground. If the weather is dry and sunny then the nuts can be cured as follows:—Erect stakes in the ground and build the plants around them so that the bottom part of the plant is facing the stake. Build up until the heaps are about 3 feet high, then cover the top and allow the heaps to remain until some nuts that were not quite ripe at the time of harvest have ripened thoroughly. When curing is finished remove the nuts from the stems and dry them in the sun.

Should the weather be unsuitable at harvest time, then pull out the plant, turn it bottom upwards and allow it to remain for 2-3 days until it has wilted, then remove the nuts and dry them.

It is important to remember in growing peanuts that—

1. The seed must be removed from the shell before planting.
2. The plants must be continually hilled up during growth.
3. Where there is much rain, plant in ridges.

8. Lima Beans.

The lima bean grown at Keravat is a small bushy plant having small yellow flowers and producing pods containing three flat white seeds in each pod. The lima bean is a legume so that, wherever it is cultivated. it improves the soil.

When planting, the seed is sown in rows 1 ft. 6 in. or 2 feet apart and 1 foot to 1 ft. 6 in. apart in the rows, and about 1-1½ inches deep. Germination takes place quickly and the plant grows quickly. Approximately 5-6 weeks after planting, the first flowers begin to appear and the first ripe seeds are ready for harvest in about 10 weeks from planting.

Lima bean will not grow in wet soils and if when they are nearing maturity, there is very much rain, then many of the plants die. Lima beans are very good food and the seed is prepared by soaking in water for twelve hours and then boiling.

9. Winged Beans.

The variety of winged bean grown at Keravat is a climber, which has purple flowers and produces a long, three-cornered pod containing a number of round black seeds. Like the lima bean, the winged bean is a legume and improves the soil.

The seed is sown in rows 3 feet apart, 2 feet apart in the rows and about 1-1½ inches deep.

When the plants are about one month old they must be staked.

Staking is carried out in the same manner as for yams. Flowering begins about six weeks to seven weeks after planting and the dry pods are ready for harvest in ten to twelve weeks.

The young green pods when about 6 inches long may be boiled and eaten, or the mature seed may be soaked in water for about twelve hours and then boiled.

10. Velvet Bean.

There are two types of velvet bean in cultivation at Keravat. One type is a climber, the other a non-climber. Both types produce short, hard, dark-coloured, fat pods containing several seeds. The seeds may be black, white, buff-coloured or mottled.

The seeds are sown in rows 2 feet apart, and in the case of the climber 2 feet apart in the rows whilst non-climbers are planted 1 ft. 6 in. apart in the rows. Plant the seed 1–1½ inches deep. Germination takes place quickly, and the growth of the plants, especially the climbing varieties, is very rapid.

About four to five weeks after planting the climbing type should be staked, in a similar manner to that used with winged beans. The bush type is not staked. The first ripe pods are ready to harvest in about three months from the time of planting.

When the ripe pods have been collected they are placed in the sun and allowed to get very dry, so that they can be opened easily, and the seed extracted. The dry seeds should be soaked in water for twelve hours before boiling for food.

11. Mungo Beans.

Mungo beans are grown in many parts of the tropics, mainly for food, but being a legume and quick growing, can be used to advantage as a green manure crop. This crop which is one of the most important legume crops grown in India and China is unknown in New Guinea and the adjacent Territories and is a crop which can be recommended for cultivation in this country.

Soil and Climate.—The soil must be well drained, and the climate moist and hot.

Preparation of Land and Planting.—The land should be hoed well before planting and cultivation between the rows maintained during growth. The seed is planted in rows 2 feet apart and spaced 2 feet apart in the rows and about ½–1 inch deep.

The mungo bean plant grows to a height of about 2 feet and contains many branches on which the seed pods are produced in clusters. The pods are short, about 2 inches long, are dark in colour when mature and covered with fine hairs. The seed is small and may be green, yellow or black in colour; at Keravat the green seeded type is grown.

The seeds germinate soon after planting and the plants grow so quickly that the crop is mature in about ten weeks.

For food the green pods may be boiled and eaten, or the dry grain boiled. It is customary in some countries to germinate the seed in boxes containing sand and when the sprouts are 1–1½ inches long the sprouted seeds are cooked and eaten.

As a green manure crop mungo bean is dug in when in full flower.

12. Pigeon Pea.

Pigeon pea is grown in all parts of the tropical world, and may be used as food for man or animals, for improving the soil and as a temporary shade for coffee or cacao. Pigeon pea is a shrub which grows to a height of 6–8 feet.

There are a number of varieties of pigeon pea in cultivation, and the varieties may be divided into two types, namely—

1. Annual.
2. Perennial.

The annual varieties grow and produce crops in 1–1½ years, after which they die out, whilst the perennial types produce crops in the first year and for some years following.

The pigeon pea is a legume, hence the soil is improved wherever the crop is grown and for this reason, plus its food value, the pigeon pea is quite a valuable crop to grow in rotation with other crops.

Soil and Climate.—Pigeon pea will grow in almost any type of soil, providing that it is not wet, badly drained or badly aerated. A tropical climate with a moderately long dry season is ideal.

Cultivation.—Where pigeon pea is to be planted for food purposes the land should be dug before planting. The planting material used is seed and this is sown in rows 5–6 feet apart, 3–4 feet apart in the rows and about 1½ inches deep; two or three seeds are planted in each hole.

The seeds germinate quickly and in a short while the plants are 6–9 inches high. Once they have reached this height and there is no danger of them being disturbed, weeding can commence. The control of weed and grass growth is kept up until the plants have made sufficient growth to shade the ground and keep down the weeds. This is generally about six to ten weeks.

Harvesting.—Some six to eight months after planting the first crop commences and the plants will bear for some time; when this first crop has been harvested, the perennial types are cut back and allowed to grow again to produce further crops. Ripe pods should not be allowed to remain on the plants as they are quickly attacked by insect pests and frequent pickings are necessary during the harvesting period.

After the plants have finished their first crop they should not be cut back if the season is dry.

After harvest the pods are dried in the sun, and the seed removed either by opening each pod by hand or placing a number of pods in a bag and beating the bag with a stick. If the latter method is adopted then the pod husks and the grain must be winnowed.

Pigeon pea is prepared for food by soaking the seed in water for about twelve hours and then boiling it.

13. Cowpea.

There are many varieties of cowpea which is a quick-growing legume. The cowpea improves the soil, the leaves and stems being good food for cattle, horses, goats and pigs. The pods when green can be boiled for food and when dry the seeds which are found inside the pods are used for food or for planting again. The cowpea seeds when cooked and eaten are very nourishing.

Cultivation.—Cowpea will not grow in wet soil, and in wet weather it will grow but will not produce seed.

Soil.—The soil for cowpeas must not be wet and heavy, although practically any sort of soil is suitable.

Preparation of the Land.—In light soil, such as pumice, the land need not be hoed, but heavier soil should be dug up before planting. Where it is necessary to grow cowpea in wet districts long ridges similar to those for sweet potatoes must be made. The ridges, however, are not made as high as sweet potato ridges.

Planting.—The seeds are planted in rows 3 feet apart and two or three seeds are planted about 2 inches deep, at intervals of 2 feet to 2 ft. 6 in. in the rows. Where ridges are made they are spaced 2 feet apart and two or three seeds are planted about 2 inches deep at intervals of 2 feet along the tops of the ridges. The seeds germinate quickly and should be showing above ground in four to six days.

The land between the rows must be kept clean until the cowpeas have grown and are covering the soil. When about eight weeks old the crops will commence to flower and first pods should be ripe and ready to pick in about ten to eleven weeks. Cowpeas are used for green manure, the crop being dug into the ground when it is flowering and allowed to rot in the soil for about one month before any other crop is planted in the ground.

Harvesting.—Cowpeas are ready to harvest when the pods have changed colour from green to light brown and are dry. When harvesting, the pods are picked by hand and spread in the sun until properly dry. When dry the pods can be opened by hand and the seeds removed, or pods can be placed in a bag and the bag beaten with a stick. This beating removes the seeds from the pods. The pod shells or husk can then be separated from the seed by standing on a platform about 10–15 feet high and pouring the mixed seed and pods out of a bag or some other container towards the ground into some suitable receptacle so that the wind separates them and blows away the light pods. The clean seed is now ready for planting or cooking.

Before cooking cowpeas, wash them with water and boil them until they are soft, then throw away the water in which they have been boiled, replace with fresh water and boil again.

REPORT ON THE AGRICULTURAL POSSIBILITIES of the YODDA VALLEY IN PAPUA.*

The floor of this valley is fairly level and is intersected by the Mambare or Yodda River and its many tributaries. Long low-lying foothills stretch out into the valley at intervals. These foothills are excellent for cultivation, but the steeper portions in the vicinity of the Main Range lose their fertility after the first cropping unless terraced.

The Chirima end of the valley is very rough but good crops are grown on the plateaus.

At Kokoda the valley runs south-east and is about 1,200 to 1,500 feet above sea-level. It is 3 to 6 miles wide and numerous creeks are to be found throughout.

The soil is of a reddish-brown colour with a similar but more impervious subsoil. Deep alluvial blacksoils occur between Yodda and Kokoda. The soil is a clay-loam and the colour is due to ferric oxide or the hydrate, which is an excellent advantage, as it helps to retain moisture without the physical disadvantages of clay. For the most part the soil is well drained and aerated. Although the soil is derived partly from hornblende there is a slight deficiency of lime owing to the high rainfall, but this is only noticeable for a short period after clearing till the soil is opened up. Humus is plentiful in the early stages.

The climate is fairly even, the temperature varying from 62° to 70° F., with little discrimination between summer and winter. Rainfall varies throughout the valley, but averages at Kokoda 130 inches per annum and at Yodda 180 to 200 inches per annum. The climate is very healthy.

There is vast opportunity for agricultural pursuits. At present, rubber (*Hevea brasiliensis*) is the only crop being planted and developed on any scale in the valley. The Government plantation at Kokoda, of approximately 120 acres of rubber about 20 and 25 years old, is yielding very well. There are four new areas of rubber already planted in the valley, namely, a small area of about 14 acres at Saga plantation (near Kokoda), 300 acres at Mamba rubber estate, about 250 acres at Komo plantation, and 47 acres at Yodda Goldfields Limited at Yodda. These areas are still very young, having been planted during the last three years, the most advanced block being the Mamba rubber estate halfway between Kokoda and Yodda. The areas of rubber are being steadily extended each year. The majority of seeds, obtained from the Kokoda plantation, have proved of excellent quality, but could be improved by selection.

Other crops suitable are coffee, cacao and kapok. A few trees of kapok at Yodda are bearing reasonably well after four years. Cacao should do well in the lower reaches of the valley as the soil and climate are excellently suited for its growth. Tea is a doubtful crop, but could be grown in small patches where the soil is of a light loamy nature. Sugar-cane grows excellently, but unfortunately there is no market.

---

* Report submitted by the Director of Agriculture, Papua.

Sweet potatoes are the main native food and they can be produced all the year round. Two crops a year may be harvested interplanted with corn. Dalo or dasheen (taro) is also a staple food and takes five or six months to mature. It is planted in June or July. Yams and manioc are grown mainly in the Chirima and Biagi villages, but will also grow well in low-lying lands. Rice and sago are not grown to any extent, but there is an excellent future for rice on the level stretches.

Bananas and pawpaws grow in abundance and are very prolific. Coco-nuts can be grown—the smaller inland variety being the best suited. Citrus growing on a small scale is quite a success, but they are readily attacked by scale and dieback if neglected.

Vegetables such as beans, tomatoes, cabbages, lettuces, cucumbers, eschalots, turnips, radishes, chokos and pumpkins are very easily raised if protected, but will also do quite well in open beds.

Cattle and pigs should do well in the valley. Berkshires and Tamworths are the best for the climate and they both cross readily with the native pig. Shorthorn cattle are perhaps the best of breeds, but beef animals also do well.

The main grasses are summer and couch, but paspalum is doing well in patches. Blue grasses, rye and kikuyu do very well, but the country is not stocked to any extent and consequently they have not been encouraged.

Pines are found in the Biagi and Chirima Districts, while hardwoods, semi-hards and softwoods of excellent quality are found in large quantities in the valley.

The valley shows excellent promise for agriculture and as freighting becomes less difficult it will no doubt show its worth in this regard.

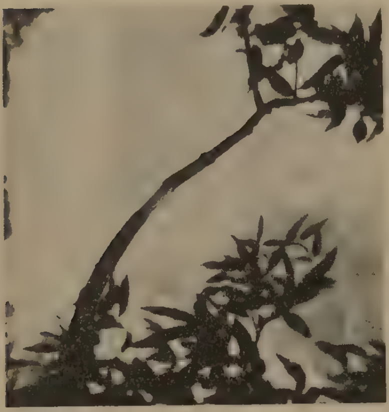
MARCOTTING.

Marcotting is adopted in the case of trees which are difficult to propagate by cuttings or to which other methods of propagation cannot easily be applied.

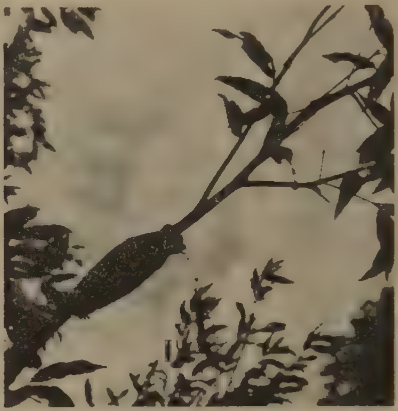
The method employed in the Botanic Gardens in Rabaul is as follows: a firm, healthy branch with well ripened wood is chosen and just below a node, 2 inches of bark, including the water-bark, is removed. After about 24 hours, when the wood is dry, it is plastered with wet adhesive soil ($\frac{1}{2}$ cow dung and $\frac{1}{2}$ loam) which is held securely in place with hessian tied with string.

It is most essential that the soil be watered daily and when the roots appear through the ball of earth, the branch is severed from the parent tree just below the roots and planted in a bamboo pot or basket.

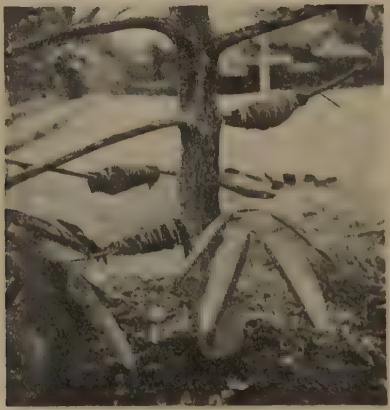
These operations are best carried out during the rainy season.—Ah Fat.



A healthy mangosteen branch with the bark cut.



The soil bound on the marcot.



Marcots on mangosteen tree.

(Photographs by Chee Hoi Meen.)

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TERRITORY OF NEW GUINEA.

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and a

More Prosperous New Year.

Rabaul. 1941-1942.

THE

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EDITORIAL NOTES.

Insect Pests.

THE use of methods of soil culture and agricultural hygiene in the control of insect pests is rather neglected in this Territory, whereas in old-established agricultural communities it is rightly considered an essential part of good farming. The shortage and high prices of imported foods have led to a rapid expansion in the cultivation of crops which produce food for native labour, such as taro, sweet potato and maize, and it is with quickly maturing crops such as these that clean methods of agriculture are so important. General neglect of such methods may be expected to increase the incidence of insect pests.

Among the most important cultural and hygienic measures are destruction of the remains of harvested crops and volunteer plants, cultivation of soil to destroy insect eggs, pupae, &c., use of clean seed, proper planting and cultivation of the crop, rotation of crops, planting at the best time of year, clean harvesting and use of seed-beds. All these practices are applicable, wholly or in part, to food crops in this Territory. The best way to illustrate their use is to use a few well-known insect pests as examples.

The larvae of the sweet potato weevil, *Cylas formicarius,* bore into the tubers and runners of the sweet potato, later pupating in the borings, and the adults feed on exposed tubers, leaves and runners. If this pest is prevalent in an area, clean farming methods are essential for its control. It is best to plant the crop as far as possible from the site of the previous sweet-potato crop, and only weevil-free tubers and cuttings should be used. If there is doubt about freedom of tubers from infestation, they can be fumigated with paradichlorbenzene before planting. As the weevil freely attacks exposed tubers, those of the growing crop should be kept well covered with soil, or deep rooting varieties can be grown. The potatoes should be harvested as they ripen, and any infested ones destroyed. When harvesting is completed, all runners and debris should be destroyed, so that all stages of the pest remaining in them may be killed. After the storehouse has been emptied of stored tubers, it should be thoroughly cleaned out, and all debris burnt.

Correct preparation of the soil by hoeing, and keeping down of weeds during the early stages of growth, are very desirable measures, because, by ensuring a more vigorous growth, they make the plants more resistant to damage by the weevil. Crop rotation is a system which works in two ways. By maintaining the fertility of the soil, it produces stronger plants, and by providing a break between one crop of sweet potatoes and the next, it greatly checks multiplication of insect pests.

The principles underlying the cultural and hygienic methods mentioned above are applicable, generally, more particularly to the management of non-permanent crops. A knowledge of the life history and habits of each pest will indicate just what steps must be taken for its control, but it will be found that the standard practices of clean farming are a sound basis for all such control measures.

It is realized that local exigencies sometimes interfere with the carrying out of activities dictated by scientific knowledge, but, on the other hand, it is evident that slipshod methods have been followed because they have been "good enough" to produce sufficient food for a labour line, even though there has been considerable loss due to insect attack. It must be realized, however, that under this system costs of production are unduly high, and that, as war conditions bring about more extensive and more frequent plantings of food crops, the trouble will be exaggerated.

Maize is a crop which, in every part of the Territory, is very badly damaged by attacks of the corn borer, *Pyrausta damoalis*, and the corn ear worm, *Heliothis obsoleta*. The usual experience when a crop is inspected is to find stems and cobs riddled by the larvae of these pests, and such attacks undoubtedly reduce the yield and produce many damaged ears. One has yet to see any serious attempt to control such infestations. Some planters operate on the system of continued plantings of maize, which provide a supply of fresh cobs throughout the year, and also ensure that insect pests will be able to reproduce continually, unchecked by any shortage of food. Volunteer plants, and isolated plants grown by plantation labourers, are also commonly seen in plantation food gardens, acting as a carry-over for pests during the period between the growing of the main crops. Such plants are usually extremely badly infested by insects, and should certainly not be allowed to exist. Volunteer tobacco plants are frequently seen where this crop is grown, and in this case the harm done is particularly severe and unnecessary, because usually only one crop of tobacco is grown each year, so that there is the opportunity to have a complete clean-up after each crop, with a lapse of several months before the next is planted. Volunteer plants bridge the gap, and greatly increase the chances of infestation of the new crop.

These remarks should indicate that there is considerable room for improvement in the culture of food crops, and that better methods would lead to more economical production. At a time like the present there is more than the normal need for efforts in this direction. The Entomological Branch of the Department of Agriculture may always be called on for any advice and help it is able to give.

PHOSPHATE DEPOSITS IN NEW GUINEA.

By R. C. Hutchinson.

Department of Agriculture, Rabaul.

Introduction.

The most important fertilizer constituents are nitrogen, phosphoric acid and potash. The constituents most lacking in New Guinea soils are potash and phosphoric acid. This has been proved directly by chemical analyses and indirectly by the remarkable results which follow the use of potassic and phosphoric fertilizers on some plantations.

Nearly all phosphoric and potassic fertilizers employed in this Territory are imported from Australia at a cost which makes their use uneconomical except on the most remunerative crops. This is greatly retarding agriculture in this Territory, where fertilizers are badly needed and would certainly be supplied more freely if their cost were not so high. One way of overcoming the difficulty would be to find local sources of these constituents from which cheap supplies could be obtained. No local source of potash of commercial importance is known, but there are several sources of phosphoric acid, the two principal being the rock on certain islands and bat guano.

Rock Phosphate.

In 1905, the Germans first discovered rock phosphate in New Guinea. About five years later, Mole Island, a unit of the Purdy Group, was worked for phosphate under the New Guinea Protectorate, but when Nauru became the important source of this commodity, the Purdy Islands' deposit was practically ignored. In 1909, the Hanseatic Pacific Expedition, led by Dr. Georg Friederici, investigated a number of islands for phosphate deposits sufficiently large to be worked. A number of hitherto geologically unknown islands, and also some islands previously examined, were visited. The summarized results of the findings of this expedition for islands within the Territory of New Guinea are given in Tables 1 and 2. In 1929, the British Phosphate Commissioners sent Mr. K. M. Fennell to New Guinea to investigate the phosphate deposits. Some of his conclusions are tabulated in Tables 1 and 2 and others will be referred to later.

In New Guinea, there are two groups of islands on which phosphate rock exists. One group, situated in the north-western corner of the Territory, consists of Wuvulu (Maty), Aua (Durour) and Manu (Allison) Islands and the other group, known as the Purdy Islands, is situated to the south-west of the Island of Manus.

Wuvulu Island is about 5 miles in length and 2½ miles in breadth at its widest part. The island is surrounded by a coral reef and there is no sheltered anchorage. The phosphate deposit, which is nearly all rock, is situated in the south-west corner of the island and is scattered over an area of about an acre. It is difficult to estimate the quantity as it is covered with dense jungle which is difficult to penetrate.

About 20 miles from Wuvulu is Aua Island, which is about 3 miles in length and about 1 mile in breadth at its widest part. It is surrounded by a coral reef which is about 50 yards wide in the south and from 300 to 400 yards wide in the north. There is no protected anchorage. A phosphate deposit is situated about ¼ mile inland on the south-east section of the island. It is about 1,000 yards in length, varies from 30 to 150 yards in breadth and is from 6 to 8 feet deep. It is nearly all rock, with a little alluvial which appears more like ordinary soil than phosphate. The deposit is intermixed with broken coral-rock, sand and mud and is covered with a thick growth of ferns and creepers. The exposed phosphate is covered with a coating of moss. Fennell (1929) estimated the quantity at not more than 80,000 tons. In 1911, the Germans prospected the island for phosphate and their sample pits are still to be seen.

Manu Island is about 37 miles north-east of Aua and has an area of 62 acres. It is only 4 feet above sea-level and the deposit of phosphate is small. There is no protected anchorage.

The Purdy Islands consist of five islands—Mole, Mouse, Rat, North Bat and South Bat—the relative positions of which are shown in Figure 1. Rat Island is the smallest of the group, being only about $^1/_{10}$th acre in area. The sizes of the other islands are given in Table 3. These areas were determined from a compass survey conducted by the author. This group of islands is more centrally situated with regard to the rest of the Territory than the preceding, and there is a well-protected anchorage between North Bat and South Bat Islands.

In general, the Purdy Islands are built up, as shown in Figure V. Surrounding each island is a flat coral reef, part of which is just above water at low tide. The width of this reef varies from about 2 chains at the narrowest parts on Mole and Mouse Islands to over $\frac{1}{4}$ mile at the widest parts on the Bat Islands. Each island is surrounded by a coarse, white beach of coral origin, behind which there is a sand embankment rising about 6 feet above high-water mark. The islands are saucer-shaped, being about 2 feet above high-water level in the centre. In wet weather, the centres are inclined to be swampy. On all the islands there are coco-nuts, vines and ferns growing and on some islands miscellaneous shrubs and trees.

On Mole and Mouse Islands, the phosphate is to be found in the low-lying centres of the islands (*see* Figures II. and IV.), where it is generally to be found, a few inches below the surface, as lumps of rock weighing 2 to 10 lb. On Mole Island, a stack of at least 400 tons of phosphate is to be found on the western end of the island. This phosphate was collected when the island was being worked by the Germans. It is illustrated in Figure A, where it is seen to be almost covered with small ferns.

On each of the Bat Islands, the phosphate deposits extend out into the sea on one side (*see* Figure III.). This suggests that, in recent years, these islands have moved closer together, thus laying bare phosphatic rock which was originally in the centres of the islands. The beach outcrop on North Bat Island is illustrated in Figure B.

The thickness of the phosphate layers varies greatly. In some places it is possible to sink a 4-in. hole without striking any phosphate, while in other places it runs to a depth of 3 feet. This irregularity of depth is to be found on all the islands and the mean depth of phosphate calculated from 32 determinations was 5 inches. In estimating the total amount of phosphate in Table 3, the depth has been taken as 3 inches, so that the estimation is a very conservative one.

The phosphate was light in weight, very porous and light to medium brown in colour. It was very heterogeneous in composition and small white particles of shell and coral were distinctly visible to the naked eye. In general appearance, the phosphate from the Purdy Islands greatly resembles samples of phosphate inspected by the author from the other phosphate islands—Wuvulu, Manu and Aua.

Samples of phosphate were collected from each of the Purdy Islands and later analysed. The results of these analyses, conducted on the air-dried samples, are given in Table 4. For comparison, the compositions of other Pacific island phosphates are given in Table 5. These figures were taken from " Corallogene Phosphat-Inseln Austral-Oceaniens " by Carl Elschner.

Comparing the results in Tables 4 and 5 it will be seen that the Purdy Islands' phosphate, and probably the phosphate from the other New Guinea islands, is not of high quality. It is very porous, readily absorbs water and contains a large proportion of organic matter. It is probably of a much later date than the deposits on Nauru and the other islands mentioned in Table 5. The rock contains a considerable quantity of lime which indicates that the phosphate is in the form of calcium phosphate. Calculating the phosphate as tricalcium phosphate for comparison, it will be seen that the New Guinea rock is considerably lower in this constituent than rock from the islands mentioned in Table 5.

Bat Guano.

Bat guano, generally consisting of the excrement of several types of bats, is to be found on the floors of caves in many parts of New Guinea. The entrances to these caves are generally situated in places difficult of acccess and, although a great many caves are known, there are undoubtedly a large number which have not yet been discovered.

Recently the author visited a large limestone cave at Kaut on the west coast of New Ireland which, according to all accounts, is one of the largest guano caves yet discovered in New Guinea. The entrance to the cave is on the face of a cliff about 70 feet above sea level. Close to the base of the cliff is an excellent schooner anchorage and the guano could probably be loaded straight into the ship by means of a flying fox, although a considerable reduction in weight would result if the guano were first dried.

The cave consisted of an outer chamber which was in semi-darkness, a large inner chamber in complete darkness and a number of small grottoes. The cave penetrated the cliff for nearly a quarter of a mile and contained many pools of crystal clear water and some very fine stalactites and stalagmites. It was inhabited by large numbers of bats varying in length from 2 to 10 inches, rats, snakes and insects. The guano, which was very moist and slippery, varied in colour from black to light brown and in places was several feet deep. The irregular depth of the guano was due to the unevenness of the cave floor which, in places, penetrated the guano. It is estimated that the cave contains from 5,000-10,000 tons of guano. Numerous samples were collected from different parts of the cave and at different depths. The minimum and maximum figures obtained are given in Table 6.

Several years ago a large bat cave inhabited by a small variety of bat was discovered in the Madang District. A sample was collected from the surface of the guano and sent to the Imperial Institute for analysis. The results are given in Table 6.

In Table 7, the composition of bat guano from the Federated Malay States and cave earth from Mozambique is given for comparison.

In the Kaut caves, the composition of the guano in the outer chamber consists of about 16 per cent. phosphoric acid and 26 per cent. lime which indicates that most of the phosphate is in the form of calcium phosphate. This guano compares very favorably with the best guano from the Federated Malay States. Guano from other parts of the cave, although containing as much as 43 per cent. phosphoric acid, was very low in lime, generally containing 1-2 per cent., which indicates that the phosphoric acid is present as phosphates of iron and alumina and not as calcium phosphate. The Madang guano contains considerably less phosphoric acid, a large proportion of which exists as phosphates of metals other than calcium, probably those of iron and alumina.

In the guano from both caves, the percentages of potash and nitrogen are low. It may be remarked, also, that the nitrogen content of bat guano is largely derived from undigested parts, such as the wings of insects, and is unavailable for plant nutrition. The total percentages of nitrogen, therefore, cannot be regarded as being entirely of immediate manurial value.

The guano in the two caves mentioned above is probably typical of the guano in most caves in this Territory.

Summary.

In New Guinea there are deposits of low-grade rock phosphate amounting to at least 100,000 tons and numerous bat caves, some of which contain large deposits of guano.

It is not considered that the quantity or quality of the phosphatic rock or guano is sufficient to consider the exportation of these commodities, but they contain sufficient phosphoric acid, either in a form suitable for direct application or in a form which can be readily made available, to meet local agricultural requirements for many years to come.

TABLE 1.—PLACES UNSUCCESSFULLY SEARCHED FOR PHOSPHATE WORTH WORKING.

Place.	District.	Investigator.	Remarks.
Alim Island	Manus	Friederiei (1909)	Formed of coral lime
Anir Island	New Ireland	Friederiei (1909)	
Baluan Island	Manus	Friederiei (1909)	Formed of eruptive rock
Buka Island	Kieta	Friederiei (1909)	
Dylup Plantation	Madang	Fennell (1929)	Traces of P_2O_5
Keule Island	Sepik	Friederiei (1909)	
Kilinailau Islands	Kieta	Friederiei (1909)	
Liebliche Islands	New Britain	Friederiei (1909)	Composed of coral lime
Lou Island	Manus	Friederiei (1909)	Formed of eruptive rock
Mait Island	New Ireland	Friederiei (1909)	
Nissan Island	Kieta	Friederiei (1909)	
Nuguria Islands	Kieta	Friederiei (1909)	
Nukumanu Islands	Kieta	Friederiei (1909)	
Pak Island	Manus	Friederiei (1909)	Formed of coral lime
Simberi Island	New Ireland	Friederiei (1909)	
Tabar Island	New Ireland	Friederiei (1909)	
Talele Islands	New Britain	Germans (1905) Fennell (1929)	Limestone containing ..21 per cent. P_2O_5
Tanga Islands	New Ireland	Friederiei (1909)	
Taku Islands	Kieta	Friederiei (1909)	
Tendanye Island	Sepik	Friederiei (1909)	Formed of andesitic eruptive rock
Valif Island	Sepik	Friederiei (1909)	Formed of andesitic eruptive rock
Viai Island	Sepik	Friederiei (1909)	Formed of andesitic eruptive rock
Other small islands adjacent to St. Matthias, Emirau, Tench and Lihir Islands	New Ireland	Friederiei (1909)	

TABLE 2.—ISLANDS VISITED BUT NOT THOROUGHLY INVESTIGATED FOR PHOSPHATE.

Island.	District.	Investigator.	Remarks.
Emirau	New Ireland	Fennell (1929)	Phosphate deposits unlikely
Komuli Group	Manus	Fennell (1929)	Of both volcanic and coral formation ; phosphate unlikely
Manus	Manus	Fennell (1929)	No indications of phosphate
Maron	Manus	Fennell (1929)	Volcanic formation ; rugged ; no indication of phosphate
Massau	New Ireland	Fennell (1929)	Phosphate deposits unlikely
Ninigo Group—			
Awin Longan Mal Pelleluhu Sumasuma	Manus	Fennell (1929)	Low, sandy flat islands of coral formation ; no indications of phosphate
Ndruval	Manus	Fennell (1929)	Coral formation ; no indications of phosphate
Pak	Manus	Fennell (1929)	Coral formation ; no indications of phosphate
Ponam	Manus	Fennell (1929)	Coral formation ; low, sandy ; phosphate deposits unlikely
Salami	Manus	Fennell (1929)	Coral formation ; low, sandy ; phosphate deposits unlikely
Salien	Manus	Fennell (1929)	Coral formation ; very low, marshy ; phosphate deposits unlikely
Sici Liu	Manus	Fennell (1929)	Coral formation ; low, sandy ; phosphate deposits unlikely
Sici Mandarin	Manus	Fennell (1929)	Coral formation ; low, sandy, marshy ; phosphate deposits unlikely
Tingwon Group	New Ireland	Fennell (1929)	Coral formation ; low, sandy, marshy ; phosphate deposits unlikely

TABLE 3.—APPROXIMATE QUANTITY OF PHOSPHATE ON PURDY ISLANDS.

Island.	Total Area.	Area of Phosphate.	Volume of Phosphate.	Specific Gravity.	Approximate Weight of Phosphate.
	Sq. yds.	Sq. yds.	Cub. yds.		Tons.
Mole	298,800	101,700	8,490	1.6	10,200
Mouse	166,900	46,800	3,900	1.7	5,000
North Bat	54,600	21,200	1,770	1.8	2,400
South Bat	201,200	88,000	7,330	1.7	9,400
Total	721,500	257,700	21,475	..	27,000

TABLE 4.—COMPOSITION OF PURDY ISLANDS' PHOSPHATE.

Constituent.	Mole.	Mouse.	North Bat.	South Bat.	Mean.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8.9	5.7	5.9	7.2	6.9
Loss on ignition	24.6	32.9	26.4	26.6	27.6
Insoluble matter	0.15	0.27	0.14	0.21	0.19
Lime	52.2	53.2	49.7	50.5	51.4
Phosphoric acid	11.7	11.2	10.4	10.0	10.8
Tri-calcium phosphate*	25.6	24.5	22.7	21.8	23.7

* = all P_2O_5 reckoned as $Ca_3P_2O_8$.

TABLE 5.—COMPOSITION OF OTHER PACIFIC ISLAND PHOSPHATES.

Constituent.	Nauru.				Ocean.		
	1.	2.	3.	Mean.	1.*	2.*	Mean.*
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	1.94	1.70	2.95	2.20	..	..	..
Loss on ignition ..	2.90	3.30	3.74	3.31	3.70	3.62	3.66
Lime	52.46	52.47	51.39	52.11	..	..	..
Phosphoric acid ..	38.79	38.72	38.46	38.66	..	..	..
Tri-calcium phosphate ..	..	84.60‡	..	84.60‡	85.90‡	85.30	..

Constituent.	Fais.			Makatea.			Angaur 1.†
	1.†	2.†	Mean.†	1.*	2.*	Mean.*	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	2.08	..	2.08	1.40	..	1.40	1.20
Loss on ignition ..	..	1.90	1.90	3.05	2.90	2.98	..
Lime	49.88	52.70	51.29	53.70	53.58	53.64	51.52
Phosphoric acid ..	37.03	38.20	37.62	37.88	38.68	38.28	39.66
Tri-calcium phosphate ..	80.93‡	83.47‡	82.20‡	82.76‡	..	82.76‡	86.76‡

* = dried at 100° C. † = probably dried at 100° C. ‡ = all P_2O_5 reckoned as $Ca_3P_2O_8$.

TABLE 6.—COMPOSITION OF BAT GUANO FROM TWO NEW GUINEA CAVES.

Constituent.	Kaut.*		Madang.†
	Maximum.	Minimum.	
	Per cent.	Per cent.	Per cent.
Moisture	21.5	14.3	..
Loss on ignition	38.2	8.4	..
Insoluble in HCl.	11.2	7.3	..
Soluble in HCl.	62.1	38.3	..
Phosphoric acid	43.1	14.6	8.9
Lime	26.2	1.3	4.3
Potash	4.1	0.2	0.9
Nitrogen	3.2	0.1	3.7

* Estimated on air-dried sample. † Probably estimated on air-dried sample.

TABLE 7.—COMPOSITION OF BAT GUANO FROM FEDERATED MALAY STATES AND MOZAMBIQUE.

(ANALYSES BY THE IMPERIAL INSTITUTE.)

Constituent.	Bat Guano, Federated Malay States.				Cave Earth, Mozambique.
	1.	2.	3.	4.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Phosphoric acid	17.52	8.60	10.86	14.17	10.92
Lime	22.27	1.81	1.86	2.32	2.42
Potash	2.01	1.12	0.88	0.88	0.35
Nitrogen..	2.47	0.81	1.52	0.84	0.81

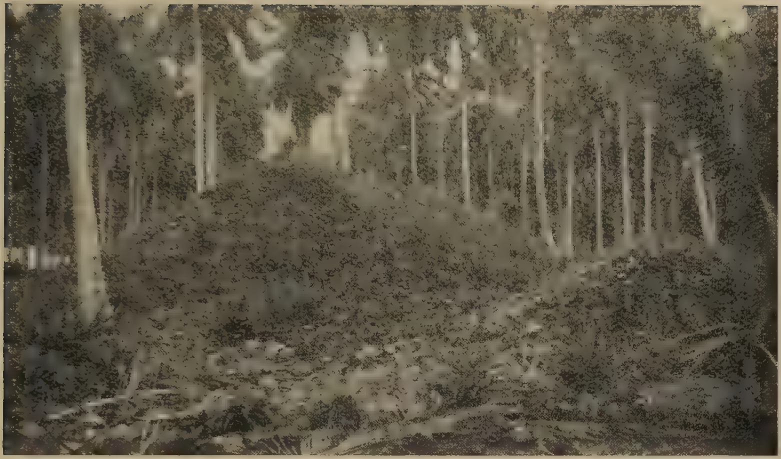

Figure A.—Phosphate Stack on Mole Island.

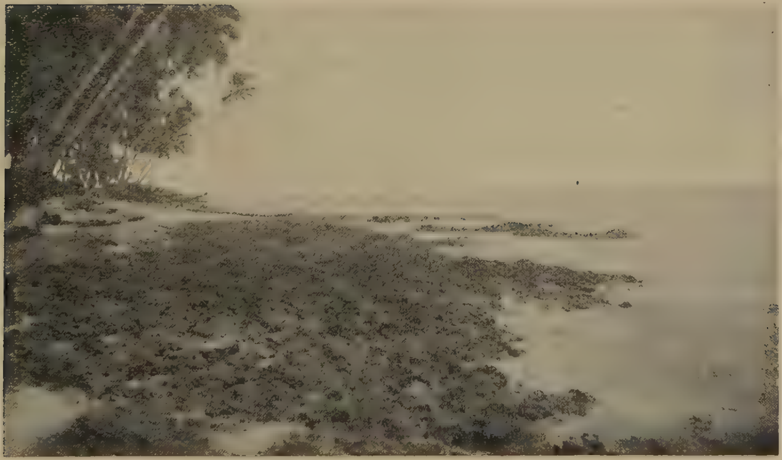

Figure B.—Phosphate Outcrop on North Bat Island.

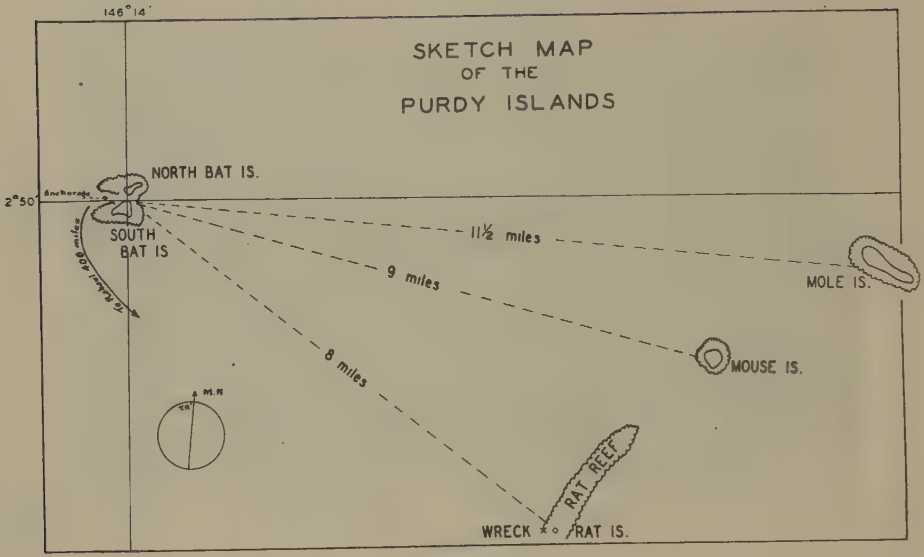
146° 14'
SKETCH MAP
OF THE
PURDY ISLANDS
2° 50'
Anchorage
NORTH BAT IS.
SOUTH
BAT IS
To Rabaul 400 miles
11½ miles
9 miles
8 miles
MOLE IS.
MOUSE IS.
M.N
T.N
RAT REEF
WRECK
RAT IS.

Figure I.

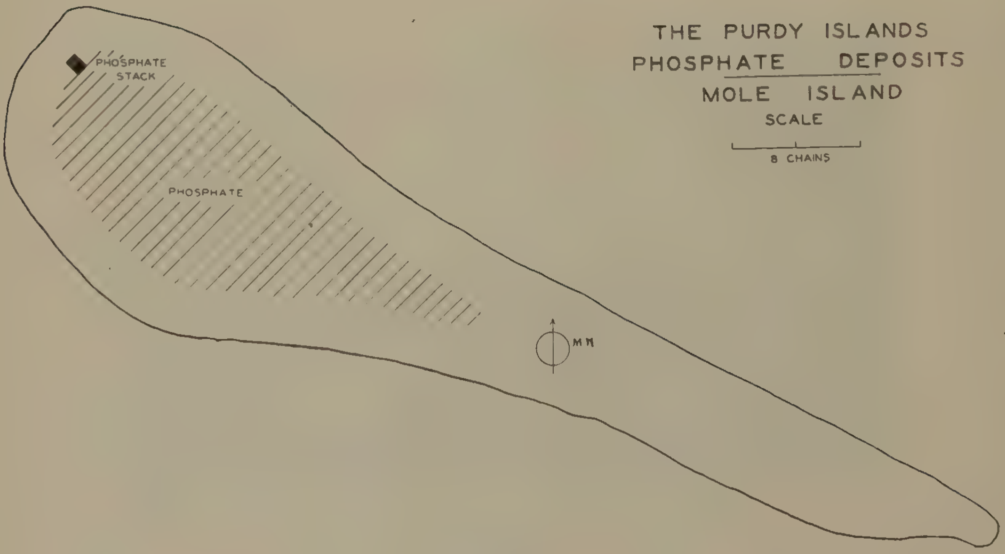
THE PURDY ISLANDS
PHOSPHATE DEPOSITS
MOLE ISLAND
SCALE
8 CHAINS
PHOSPHATE
STACK
PHOSPHATE
MN

Figure II.

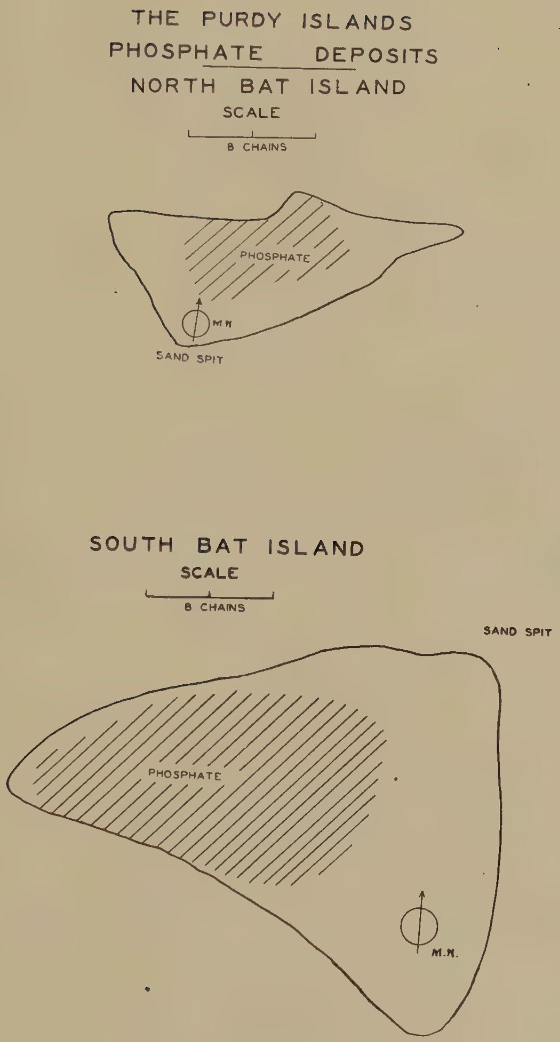
THE PURDY ISLANDS
PHOSPHATE DEPOSITS
NORTH BAT ISLAND
SCALE
8 CHAINS
PHOSPHATE
M N
SAND SPIT
SOUTH BAT ISLAND
SCALE
8 CHAINS
SAND SPIT
PHOSPHATE
M.N.

Figure III.

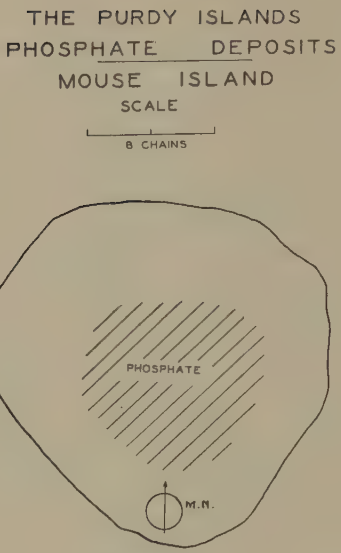
THE PURDY ISLANDS
PHOSPHATE DEPOSITS
MOUSE ISLAND
SCALE
8 CHAINS
PHOSPHATE
M.N.

Figure IV.

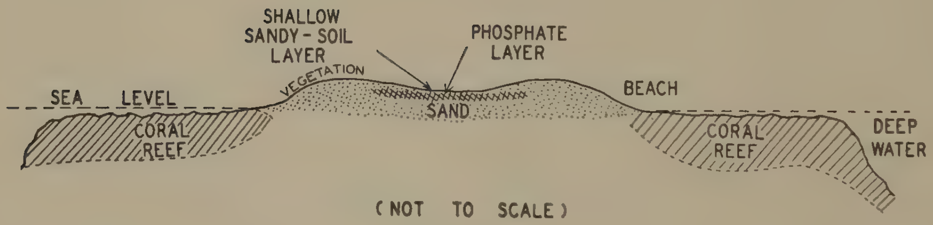
SHALLOW
SANDY - SOIL
LAYER
PHOSPHATE
LAYER
VEGETATION
SEA LEVEL
BEACH
SAND
CORAL
REEF
CORAL
REEF
DEEP
WATER
(NOT TO SCALE)

Figure V.

THE CONVERSION OF COCO-NUT OIL INTO A SOLID CRYSTALLINE MASS.

While engaged in the study of thermal decomposition of coco-nut oil, J. Banzon (*The Philippine Agriculturist*, Vol. XXVI., No. 5, p. 399) observed that a particular catalyst had the unique property of converting coco-nut oil into a crystalline solid mass.

The process is the simple distillation of coco-nut oil with ferric oxide or finely divided iron. The distillate thus obtained is dark-yellowish with a bluish fluorescence. On cooling, it sets to a crystalline greenish-yellow mass, which may be purified by repeated washings with methylated spirits.

The purified product is a light, white, crystalline powder, tasteless, and with a faint odour similar to stearic acid. It melts sharply at 55° C., to a clear transparent, colourless liquid, and solidifies to a hard, rather brittle, crystalline solid. Owing to its close resemblance to paraffin, this solid may possibly be used interchangeably with the latter, as, for example, in candle-making.

RUBBER PRODUCTION IN NEW GUINEA AND PAPUA.

(Continued.)

By R. E. P. Dwyer, B.Sc.Agr.

Department of Agriculture, Rabaul.

Land Acquirement in New Guinea and Papua.

Agricultural and pastoral leases are the main systems of land tenure in both Territories if the freehold expropriated properties in the Mandated Territory and certain Crown lands of limited area in Papua are excluded.

Land acquirement is cheap in both Territories and the rental charges are very similar although the actual means of obtaining the land for alienation are somewhat at variance. The system in Papua, where so much land is bought annually by the Government either for alienation or reservation purposes, has already been mentioned.

(*a*) *Leases for Less Than* 30 *Years.*(21)—Rental in both Territories is 5 per cent. of the unimproved value of the land, subject to re-appraisement every ten years. The Papuan law provides that the rental shall not exceed 6d. per acre per annum during the first ten years. In Papua, a rental of 3d. per acre per annum is charged as compared with approximately 6d. per acre per annum in New Guinea.

(*b*) *Leases for* 30 *Years or More.*(21)—Rental of 5 per cent. of the unimproved value of the land is payable in both Territories (generally 3d. per acre in Papua and approximately 6d. per acre in New Guinea), but in the case of a lease of less than 1,000 acres in Papua, no rent is payable during the first ten years.

In New Guinea, the Administrator has the power to remit rent during the first ten years, but in practice, he does not do so. Re-appraisement is effected every twenty years in both Territories.

Survey-fees.—The rates of survey-fees payable in New Guinea are considerably higher than those in force in Papua. The survey-fee for a block of 600 acres in Papua is £47 11s. as compared with a fee in New Guinea of £75, in addition to which there may be charged in New Guinea, travelling expenses to the site of the survey and other charges related to this.

The terms upon which agricultural land can be obtained in Papua are extremely easy to the settler—he can obtain a leasehold of any class of land up to 99 years. This long-term lease is favoured in both Territories.

In Papua, upon making application, the following deposit-fees are required: 100 acres or less, £1; up to 500 acres, £2; up to 1,000 acres, £5; and £5 for every addition of 1,000 acres or portion thereof; and a fee of 30s. for lease.

All agricultural lands that have been alienated by the Crown have been assessed at an unimproved value of 5s. per acre (rent, 3d. per acre).

In the years 1912, 1933 and 1939 the lands of Papua were held as follows:—

——	1912. (22)	1933. (23)	1939. (24)
	Acres.	Acres.	Acres.
Area of land held by natives	56,563,582	56,899,003	56,175,985
Area of Crown land	1,032,049	833,618	182,226*
Area of Freehold land	26,547	22,932	23,490*
Area of Leasehold land	332,422	190,047	192,099*
Area of Territory	57,945,600	57,945,600	57,945,600
Area of Territory surveyed	..	..	387,815

* Surveyed.

The total area of land purchased from the natives and land declared for other purposes was 1,019,814 acres in 1933—less than 2 per cent. of the Territory; in 1912 the figure was 1,382,018 acres or $2\frac{3}{4}$ per cent. of the Territory. At the 30th June, 1938, it was 1,763,833 acres, and 1,769,705 acres at the 30th June, 1939, 5,872 acres being purchased during the year.

During the German administration of the Territory of New Guinea, land was granted under freehold title after the fulfilment of certain conditions. When the Territory was placed under the Mandate control, this policy was discontinued, and a leasehold system was introduced under the Land Ordinance of 1922. It was then specified that the maximum area that could be held by one person as an agricultural lease must not exceed 2,000 hectares, and the unimproved capital value of the land not more than £5,000. This Ordinance has since been modified and areas up to 4,000 hectares (10,000 acres approximately) have been granted, the limit to be taken up being left to the discretion of the Land Board.

The term of lease may be for any period, not in excess of 99 years. The annual rental is 5 per cent. of the unimproved value, which is appraised every twenty years.

The average general appraisement for the first twenty years is £1 5s. per hectare, equivalent to an annual rent of 1s. 3d. per hectare. The rental paid per individual for agricultural leases ranges from under £6 per annum for leases not exceeding 100 hectares (roughly 250 acres), £6 to £15 per annum for areas up to 250 hectares, £16 to £30 per annum for areas between 250 and 500 hectares. A very few companies and individuals pay rentals ranging from £31 to £62 per annum for areas between 500 and 1,000 hectares and only a couple exceed this payment. The average rental for agricultural leases here probably does not exceed £15 per annum, which is very reasonable rental, although not so liberal as the rates in Papua.

In Papua, the rental of agricultural leases for the whole term of 99 years cannot exceed the following amounts, subject to a clause in voluntary forfeiture—"If on any appraisement the rent is raised by more than one-third, the lessee may disclaim the lease and is thereupon entitled to receive compensation for his improvements":—

	Rental per acre.
First twenty years—	d.
First ten years (if not exceeding 1,000 acres)	nil
Second ten years	3
Second twenty years	4
Third twenty years	$5\frac{1}{3}$
Fourth twenty years	$7^{1}/_{9}$
Balance of lease	$9^{13}/_{27}$

It was laid down also that the maximum area of land which shall be included in any agricultural lease granted in respect of any application shall not exceed 5,000 acres. It is likely that this has lately been modified as in New Guinea.

In both Territories it is provided that one-fifth of the land comprised in an agricultural lease must be planted within the first five years; two-fifths within the first ten years; and three-fifths within the first twenty years; while during the remainder of the term, three-fourths of the land so suitable must be kept planted. If such is not done, the lease may be cancelled.

It is also prescribed by land regulation that the lease must be planted with approved tropical crop plants, and, in both Territories, rubber is specified as one of these.

It is the procedure of land acquirement (but not the terms) which is unwieldy in the Territory of New Guinea and it would seem that the Papuan system is better.

The procedure at present adopted entails that intending settlers in this Territory are required to enter into almost direct negotiations with the natives and bargain for their lands, &c., and the methods of determining compensation to natives could be given a more definite basis.

It has been suggested by interested settlers and others that the particular departments which are responsible for native welfare should indicate what districts or areas are, or conversely, are not, over-alienated in relation to the native population requirements. Thus the onus would be on the Administration and officers concerned to allow adequately for present requirements, and for any increase in population in areas where this is expected.

An applicant, having selected an area of land suitable for his purpose in any district in the Territory of New Guinea, ascertains from the native owners that they are willing to sell the land to the Administration and applies to the Lands Department through the District Officer controlling the district in which the land is situated. Obviously an intending applicant, resident in the district and well known to the natives, has the best chance of obtaining land under these conditions. The native owner must be willing to sell the land to the Administration before it can be selected.

The actual procedure of application is similar in Papua and New Guinea though in the latter Territory, the fees are somewhat higher.

In New Guinea, application is made on a printed form and must be accompanied by the necessary fees which vary according to the area and are returned if the application is not granted. Thus, to take up an area of 100 hectares, the cost would be—

	£	s.	d.
Registration-fee	0	10	0
Deposit	2	0	0
Survey-fee	56	5	0
Total	58	15	0

It is necessary to deposit only one-quarter of the money for survey-fees with the application in New Guinea; the balance must be paid on completion of the survey.

The application having been made and lodged, is, in due course, advertised in the *New Guinea Gazette,* and, subsequently, it is heard by the Land Board, when the applicant may attend and state his case.

In Papua, the survey-fees, fixed by regulation, are equal to the actual cost of the field survey, plus 15 per cent. for inspection and office work, and are payable in respect of application for leases of an area exceeding 100 acres.

Land Alienation—New Guinea.

TABLE No. 10.—DETAILS OF LAND ALIENATION IN NEW GUINEA.

—	June, 1937.	June, 1938.	June, 1939.	June, 1940.
	Hectares.	Hectares.	Hectares.	Hectares..
1. Total area alienated	294,745	300,775	361,821	(*b*) 365,602
2. Percentage of total area alienated ..	1.2	1.25	1.5	1.52
3. Freehold land	(*a*) 139,741	(*a*) 154,747	210,869	210,869
4. Agricultural leases	50,113	56,013	53,599	56,079
5. Pastoral leases	3,700	3,700	3,843	3,843
6. Total leasehold lands	55,913	61,813	(*c*) 60,585	(*c*) 63,078
7. Number of agricultural leases	383	..	412	434
8. Total area under European cultivation ..	101,265	105,940	106,085	110,878
9. Percentage of total area of New Guinea under cultivation	.42	.44	.44	.46
10. Percentage of alienated area under cultivation	34.3	35.2	29.3	30.3

(*a*) Titles issued only.
(*b*) Includes 80,919 hectares of Administration land plus 10,736 hectares vested in the Director of District Services.
(*c*) Includes five other classes of leases.

Table No. 10 gives the particulars of land alienation, to date, in the Mandated Territory of New Guinea. It will be seen that by June, 1940, 365,602 hectares, equivalent to approximately 1½ per cent. of the total area of the Territory, which is estimated at 24,086,440 hectares (or 59,517,593 acres), had been alienated. Only about one-third of the total alienated area is under cultivation, which is less than .5 per cent. of the total area of the Territory. It should also be noted that a little less than 50 per cent. of the land for which freehold titles had been issued is under cultivation.

TABLE No. 11.—TOTAL AREA ALIENATED, OLD GERMAN PROTECTORATE.(25)

Name of Territory.	1911.	1912.	1913.
	Acres.	Acres.	Acres.
Bismarck Archipelago	240,018	271,825	307,293
Kaiser Wilhelmsland (New Guinea Mainland)	188,168	180,007	192,458
Total area (acres)	428,186	451,832	499,751
Total area (hectares)	173,355	182,928	202,328
Total cultivated area (acres)..	64,599	73,317	85,940

Most of the land alienated in the German times was under freehold tenure although the Germans also had a system of leasehold whereby about 2,100 hectares (or about 5,189 acres) could be taken up for small trading sites, &c.

The main purpose for including the table showing land alienated in the German times is to point out the position of freehold land in the Territory at the present time. The 202,000 hectares alienated in 1913 differs little from the amount of freehold land to which titles have been issued up to the present time. In New Guinea, the position of land titles is still most involved as a number of inchoate (uncompleted) titles were recorded in the German Ground-book. It is known that the legal clarification of the position of freehold land here will take several years to complete. The titles of some large virgin properties may probably be declared valid and others will not—hence the heading, "freehold land under titles issued". Where the German *Fiscus,* controlling the government and other property, was satisfied with the terms of acquisition and that all native claims had been met, a clear title was issued. The cost of such land was usually at about 2s. per acre or 5s. per hectare and payment could be spread over several years. In the years immediately preceding the war, in 1914, the price of such land had risen in many places to as much as £1 per hectare. It is interesting to note that permission to take up about 50,000 hectares of land had been granted by the German Government to the German New Guinea Company when they relinquished their charter rights over the Territory.

Population and Number of Indentured Labourers in Papua and New Guinea.

Various estimates of the native population of the Mandated Territory have been made, as, for example, in 1935 an estimate by the Department of District Services and Native Affairs was 666,000, approximately, and this estimate was increased to 750,000(26) in 1936-37. Since that time, no estimates have been made, the position being too obscure as shown by the fact that the enumerated population in 1939-40, 668,871 natives, was greater than the estimated total population five years previously.

The reason for this can be readily seen by referring to the figures in Table 12, showing the area under government control.(27)

TABLE No. 12.—CONTROLLED AREAS IN NEW GUINEA.

——	Total Area.	Area under Control.	Area under Influence.	Area under Partial Influence.
	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.
30th June, 1939	93,000	38,790	9,660	9,125
30th June, 1938	93,000	37,370	10,040	8,695

Thus, it will be seen that by June, 1939, only 41.7 per cent. of the total area was under full control, 10 per cent. under the influence of the Government, and almost another 10 per cent., under partial Government influence. The population of approximately 40 per cent. of the total area has not been enumerated, and, when it is, the total may not fall short of the 800,000 to 1,000,000 range.

If the total population amounted to 750,000 natives, there would be 32 hectares, or almost 80 acres available to each native man, woman and child in New Guinea. If it were 900,000 natives, 26.5 hectares or 64 acres (approximately) would be available to each native.

The density of population probably ranges somewhere between eight to ten natives a square mile for the whole Territory, which can be considered relatively sparse considering the land and food supply available.

Table No. 13 gives particulars of the distribution of the enumerated population on the mainland and on the various islands of New Guinea. The numbers enumerated for the Bismarck Archipelago, Bougainville and the other islands cannot be expected to change much except by natural increase or decrease. A portion of the rugged interior of New Britain seems to be the only area in this island not accounted for. The native population of the hinterland of New Guinea has not yet been fully accounted for, e.g., the enumerated population in 1939 was almost double that of 1930, *see* Table 13. It will be seen that the greatest population is available in the Sepik, Madang and Morobe Districts of the mainland, where the plantation industry is least developed.

TABLE No. 13.—NEW GUINEA—ENUMERATED POPULATION.

District.	1929–30.			1933–34.			30th June, 1939.		
	Males.	Females.	Total.	Males.	Females.	Total.	Males.	Females.	Total.
New Britain ..	42,244	39,343	81,587	55,531	42,833	96,364	46,786	46,433	93,219
New Ireland ..	19,475	18,941	38,416	24,360	18,364	42,724	18,834	18,401	37,235
New Guinea Mainland	102,638	94,410	197,048	139,739	121,901	261,640	194,274	194,703	388,977*
Bougainville (Kieta District)	19,812	19,075	38,887	22,070	19,449	41,519	22,785	23,697	46,482
Admiralty Islands (Manus)	6,894	7,173	14,067	8,033	6,911	14,944	6,681	7,031	13,712
Total in Villages ..	191,062	178,942	370,005	217,057	209,072	426,329	289,360	290,265	579,625
Indentured ..	..	..	30,130	..	..	30,594	..	..	41,675
Constabulary, Patients and Mission Schools	..	..	..	..	..	..	..	..	5,983
	191,062	178,942	400,135	217,057	209,072	456,924	289,360	290,265	627,283

	Males.	Females.	Total.
* Sepik	75,973	72,748	148,721
Madang	56,979	55,016	111,995
Morobe	61,322	66,939	128,261

There are no true counts of the population of Papua, though some estimates have been given. It would appear that the native population is not nearly so dense as that in the Mandated Territory. There are estimates ranging from 200,000(28) to 500,000(29) natives. In 1935, there was a very approximate estimate of 275,000 population, apparently partially enumerated.

This short discussion on the population is designed to indicate that the labour available is not inexhaustible in either Territory and would prove an adequate restriction of plantation production in these countries.

Indentured Labour.

Table No. 14 gives the particulars of indentured labourers in New Guinea and Papua, as far as available in this Department. In the last ten years, the number of native labourers indentured in New Guinea has increased by at least 10,000 natives.

TABLE No. 14.—PARTICULARS OF INDENTURED LABOURERS—NEW GUINEA AND PAPUA.

Year.	Enumerated Population, Territory of New Guinea only.	Total Indentured Labourers.		Indentured Labourers on Plantations, Territory of New Guinea.	
		Territory of New Guinea.	Papua.		
1914*	152,075	..	11,383	17,529	Early years for comparison— In 1890— 869
1922	251,017	..	..	20,155	In 1895— 2,246
1923†	335,258	..	..	20,081	In 1898— 2,348
1930	400,135	30,138	11,000‡	—	In 1908— 8,275
1933	401,129	30,595	..	17,369	In 1909— 8,311
1935	456,924	..	12,588	17,269	In 1910— 9,460
1936	478,686	36,927	..	—	In 1911—10,984
1937	500,040	..	..	19,760	
1938	542,394	40,259	..	20,855	
1939	627,283	41,849	18,478§ (9,648)	20,657	
1940	668,871	39,344	19,733§ (9,759)	20,477	

* To 30th December—Other years to 30th June.
† Counted population only.
‡ Approximation only.
§ Papua—Also includes non-contract labour but not administrative labour. Contract labour included in brackets.

With the expansion in rubber and gold production and the oil search, it would appear that the number of labourers employed in Papua is also on the increase. Furthermore, governmental activities have increased alongside the recognition of Papua's strategic importance to Australia. It would appear that more casual labourers are employed in Papua than in the Mandated Territory. In normal times, more than twice as many natives are employed in the plantation industry in the Mandated Territory as compared with Papua, and the drain on labour in the Territory is correspondingly greater.

TABLE No. 15.—PARTICULARS OF EMPLOYMENT—NATIVE POPULATION—NEW GUINEA.

—	1936–37.	1938–39.	1939–40.
Total Population Estimated	750,000	..	..
Native Population Enumerated	542,394	627,283	668,871
Native Officials	11,027	11,216	11,465
Indentured—			
On Plantations	19,760	20,657	20,477
Mining	7,394	7,162	7,105
Administration	1,577	2,190	1,956
Domestic	4,224	4,498	3,385
Shipping, Commerce, Industry	7,220	7,107	6,238
Miscellaneous	84	61	183
Total Indentured	40,259	41,675	39,344

Table No. 15 gives further particulars concerning the employment of the native population in the Mandated Territory. It will be seen that the number of natives indentured has been on the increase until 1938-39. The war has already had its effect on the number of natives employed (*see* figures for 1939-40).

It may be taken that approximately 40,000 natives are indentured each year, that is equivalent to approximately 6 per cent. of the enumerated population and about 12–13 per cent. of the total male population. It must be remembered that a considerable proportion of the male population is not available for indenture, being either too young or too old; also, allowances have to be made for males necessary to conduct normal village life. It is also pointed out that sick natives and those in uncontrolled areas are not available for recruiting. The natives from high levels in the hinterland are not suitable for work under coastal conditions, as they readily succumb to malaria and other diseases, and are more suited to work on high levels where they are fully acclimatized. It is seen, also, that about 11,500 natives are regularly employed as native officials and about 7,000 natives in the gold-mining industry. A proportion of the natives are also independent producers. It is thus quite probable that nearly 50 per cent. of the enumerated male population is not available for work on plantations. It is obvious that as far as the Mandated Territory is concerned, where any considerable extension of the plantation industry occurs, the labour position would provide a definite limit to such development. There is also the question of how far it is advisable to employ natives in the plantation industry without, to some extent, encouraging their future independence.

This entails such considerations as administrative policy, general intelligence of the natives, &c., which it is not possible to discuss in this article. The finding of the Committee on Native Labour Conditions will prove most helpful in assessing such possibilities.

The Amalgamation Committee gave the following comparative statistics for the two Territories at June, 1939. Populations of the Territories are as follows:—

——	Papua.	New Guinea.
European	1,488	4,445
Asiatic..	..	1,838
Native (approximately)	200,000 (enumerated)	581,342 (enumerated)

Labour Conditions.

Papua and New Guinea Compared.—This is a most important subject as practically the whole of f.o.b. cost of production for any plantation product is linked with the labour position in the two Territories. The minimum native wages permitted in the two Territories are as follows:—

——	Papua.	New Guinea.
	Per month. *s. d.*	Per month. *s. d.*
For general labour	10 0	5 0 For first contract 6 0 For subsequent contracts
For mining labour	12 6	10 0 For heavy labour, including mining

In addition, in New Guinea, a bonus is usually paid to natives on entering into indenture—20s. for a three-year contract, 15s. for a two-year period, and 10s. for one year.

The rates paid in both Territories are in addition to sustenance, clothing, equipment, accommodation and medical attention.

A considerable proportion of both Papua and New Guinea is only under partial or not yet under Government control, though these areas are continually decreasing. It is only from the controlled areas that labour can be recruited. Districts and prescribed areas within particular districts may be closed to recruiting when over-recruiting or other causes necessitate this. The indenture system is in force in both Territories and, under the circumstances, is the only workable system.

The native races in these islands are the product of many migrations and many different races and types are present in both Territories. In many cases the people have risen little above the stone age culture and the villages or small groups usually constitute their main social and economic organizations. Languages and dialects are most abundant, often varying within a few miles.

In Papua, the "Motu" language is being spread as far as possible, as the *lingua franca*, while in New Guinea, pidgin English is widely used. In the Bismarck Archipelago, however, there has been a tendency for the Blanche Bay dialect to spread amongst the natives themselves.

Labour is recruited by private enterprise in both Papua and New Guinea and the natives work under a system of indentures entered into under Government supervision by which the native is bound for a specified period to work for the employer. A breach of these indentures by either employer or native is punishable under the Native Labour Ordinance, though a good deal is left to the discretion of the officers administering this Ordinance. This Ordinance also provides for all the living conditions, conditions of payment, &c., under which the native works and the employer must also fulfil his obligations. Periodical inspections are carried out on all plantations to see that these conditions are observed and the labourer is very well protected as to conditions of employment.

In both Territories, plantation and general labour is legally permitted to engage for a period of three years after which they are usually returned to their villages. The practice in Papua is to engage for only about eighteen months, or two years, as they are apparently averse to signing on further. In the Mandated Territory two and three-year contracts are more common.

TABLE No. 16.—MANDATED TERRITORY—LABOUR RENEWAL OF CONTRACTS.

	Period of Service.			Total Renewals.
	For One Year.	For Two Years.	For Three Years.	
Year—				
1938–39	1,364	5,466	2,822	9,652
1937–38	973	3,240	1,368	5,581
Totals for two years	2,337	8,706	4,190	15,233
Relative percentages for the two years considered	15 per cent.	57 per cent.	28 per cent.	..

The percentage of labourers making three-year contracts when originally signing on has not been tabulated by the District Office. It would be greater than the figures shown for the labour renewing their contracts and making their second or third papers. In 1938-39, 41,849 natives were indentured, hence the 9,652 renewed contracts represented 23 per cent. of the total indentured labour compared with approximately 14 per cent. the previous year.

A great proportion of the labour recruited is brought in from areas which are far removed from the centres of plantation industry and in such cases the cost of recruitment and transport is high, often amounting to £7 and £8 per head.

In 1916, some of the Papuan planters complained that, although the limit of indenture is three years, the natives limit themselves to one year indenture, because they will not stay away from their villages longer. The "boys" have to be trained to tap the rubber and continued re-training is necessary with every new batch of "boys". In evidence before the Amalgamation Committee, 1939,(30) with very few exceptions, the Papuan employers expressed themselves content with the Papuan practice. Papuan employers stated that the labourer would seldom sign on for more than two years and that, if he did, then he was worked out in the third year. New Guinea employers, on the other hand, said that the native was of very little use in the first six months and, if he were not allowed to serve for three years, the contract would not be of much value to them. It appears that a good deal of such evidence is of little value in assessing the true position and that many other factors are involved in this divergence of policy. Logically, it would seem that the more practice natives had with tapping and factory work, the more proficient they would become. There are other valid arguments for and against making the term of indenture too long, which are not within the province of this article.

Natives from certain localities are regarded as more intelligent for certain work (such as tapping) than others. This fact is true for both Territories. It is believed that certain groups of natives in Papua with rather pronounced Polynesian strain are more advanced than the better tribes here. This contention may be true but, in any case, whether any superiority is due to better natural intelligence than to longer association with the type of work they are engaged on, would be difficult to prove.

It was formerly a common idea that even the best natives from the Mandated Territory would not make good rubber tappers. An old planter, who has had many years of association with rubber planting in Java and Malaya, said that some old tapping done at Aropa, Bougainville Island, was excellent. To further test this contention, a former Papuan planter now working rubber in this Territory, sent five New Ireland "boys" to Samarai in Papua and in no time they were tapping rubber as well as the Papuans and carrying on the same task. Later experience has shown that a proportion of the labour employed is not good at tapping as compared with the labour in Papua, and probably in other parts of the world, but they are readily absorbed in other tasks.

At the commencement, it was found that the natives tended to carve the trees and in Papua are often referred to as "butchers". Before three weeks, the better tappers come to the fore and, with close supervision, become quite proficient. This exactly tallies with experiences on recently opened-up tapping areas in the Territory of New Guinea.

The greater proportion of the natives can be taught to tap rubber very well and also to carry out all factory procedure. Some of the tapping work one has seen on plantations near Rabaul and at Magaria, Madang, is very good, although there is a tendency for some of the natives to become heavy-handed, and tap too deeply, unless constant supervision is employed. It does seem that Chinese and Eurasians could be employed very usefully in such supervision, particularly if they were experienced tappers themselves.

The labour problem is, however, of paramount importance when considering the development of any new planting industry in New Guinea or, in fact, any of the South Sea Islands. In a special commission's report(31) on trade in the South Pacific in 1916, practically all of the numerous witnesses called attention to this fact.

It is only recently that a representative commission with wide powers(32) examined witnesses from all parts of the Mandated Territory and closely studied the wide aspects of this important subject, and a comprehensive report is to be furnished.

The area suitable for cultivation in this Territory, as in Papua, has never been accurately determined. It is certain, however, that much more suitable land than labour is available.

It is not intended to discuss the pros and cons of introducing labour under indenture or contract from other countries to develop plantation industries here, such as was done in Malaya, Sumatra, Fiji and Samoa. So far the need for such action has not arisen here and the future holds so many indeterminate factors that it is not intended to deal with this subject now.

It is pointed out, however, that a few special artisans have been brought in under contract and the author believes that the possibility of the introduction of key workers for certain advanced works should not be overlooked. As a rule, the local Asiatic population belongs to the trading more than to the genuine agricultural class. What are particularly lacking in New Guinea are intelligent Chinese, Malays or Javanese trained in bud-grafting, both for cacao and rubber propagation. Some of our most intelligent "boys" are capable of doing this work but do not work with sustained interest, tending to become careless. Further trained workers who have been used to plantation and factory routine in the more advanced tropical countries would be of great use. In the long run, they would help to develop the industry and cause our own natives to take a more intelligent interest in such work.

LABOUR COSTS IN NEW GUINEA.

It would be practically impossible to arrive at the labour costs involved for rubber production in this Territory, as, at the present time, only old-established rubber is being tapped. It is likely that labour costs for rubber production would be somewhat higher than for copra production. Some general particulars of the labour costs on coco-nut plantations are given as a guide. It is known that the cost of labour varies greatly with the size of the plantation, efficiency of management, distance from recruiting centres, costs of tools, rice, issues, &c. Forsayth,(33) in evidence, stated that, previous to 1911, the costs varied between 60 to 70 pfennigs a day (7d. to 8d. a day). This sum covered everything, as follows:—Recruiting-fee (£1 to £5) for three years; wages (£4 to £7 a year); government depot fee (5s.); medical attention; food and other etceteras. This planter was well known locally and many natives came into his employ without any recruiting-fee. Also a large amount of native food was grown on the estate to reduce the cost of labour.

The actual wages paid at the present time have shown very little increase on those figures, e.g., 6s. a month is equivalent to £3 12s. a year; 8s. a month equals £4 16s.; and 10s. a month (which is only paid to the better type of "boys") equals £6 per annum.

At the present time, according to most planters, wages and issue costs are said to range from 6d. to 8d. a "boy" a day, but when costs of recruiting, supervision, transport and medical attention are taken into account, the labour costs have been variously estimated to range from 9d. to 1s. 3d. a unit a day. Commonly, the labour costs are given as somewhere between 10d. and 1s. a day. There is undoubtedly a wide range of labour costs on plantations here, probably ranging from £12 to £20 a year, depending on several factors, as indicated. It would appear that the average "all in" cost per annum a labourer, in New Guinea, is somewhere between £16 and £18 a year on most plantations, or about 6s. 6d. to 7s. a week.

LABOUR COSTS IN PAPUA.

There are no recent particulars concerning the cost of labour in Papua. It is known that the monthly wages have not altered for many years, hence, the estimates given by Staniforth Smith(34) for cost of labour should not be far wide of the mark and they are as follows:—

> The cost of native labour depends largely upon whether native food is grown on the plantation or in the vicinity of the industry that is being carried on. If a large proportion of the diet of the employees consists of bananas, sweet potatoes, yams, taro, tapioca and maize, the regimen will ensure better health and decreased expense. On a well-managed plantation, the cost (including everything) a working day for each labourer should be well under 1s. Assuming, however, that the native labourers are fed entirely on imported foodstuffs (which is quite usual) at local store prices, the cost is only about 1s. 2d. a day.

COST OF AGRICULTURAL LABOUR FOR ONE YEAR.

Smith's 1912 figures.				Adjusted 1940 figures on same basis.			
	£	s.	d.		£	s.	d.
Rations—							
Meat—1 lb. per week at 9d. per lb.	1	19	0	.. .. ..	1	19	0
Tobacco—1 stick per week—52 sticks at 3s. 6d. a lb. of 26 sticks	0	7	0	1 stick at 5s. 6d. per lb. .. (If 3 sticks supplied—£1 13s.)	0	11	0
Soap—2 oz. per week, 6½ lb. for 52 weeks at 1s. per bar of 2½ lb.	0	6	0	.. .. ..	0	6	0
Sugar—1 lb. per week at 3½d. per lb.	0	15	2	Sugar—1 lb. per week at 4d. per lb.	0	18	0
Rice—1½ lb. per day, 547½ lb. for 52 weeks at 8s. 6d. per bag of 56 lb.	4	3	1	.. .. ..	4	3	1
Salt—1 oz. per week, 3¼ lb. for 52 weeks at 2d. per lb.	0	0	6½	.. .. ..	0	0	6½
Cost of Food Supply	7	7	4½		7	17	7½
Other Expenses—							
Wages at 10s. per month	6	0	0	.. .. ..	6	0	0
Fees for signing on and off	0	6	0	.. .. ..	0	6	0
Recruiting fees and fares	3	10	0	.. .. ..	5	0	0
Return passage	0	10	0	.. .. ..	0	10	0
Blanket	0	5	0	.. .. ..	0	5	0
Sulus (Lap Laps) 4 at 1s. each	0	4	0	.. .. ..	0	4	0
Total	18	2	4½		20	2	7½

After deducting 52 Sundays, a total of £18 2s. 4½d. would amount to 1s. 2d. a working day. It is commented that 4 ounces of coco-nut a day may be substituted for sugar. Native vegetable food may take the place of rice to a large extent. When fish are plentiful, even the purchase of meat may be greatly reduced. The recruiting-fees are often saved by planters recruiting their own labour.

It would seem that supervision, medical expenses, housing, percentage of labour lost through illness, tools supplied, some forms of licences and extra issues (box, bowl, spoon, fish-liver oil, &c.), are not taken into account in the above estimate. It is also pointed out that the prices of certain commodities, particularly tobacco, have changed from the old basis given. It is estimated that the £18 2s. 4½d. adjusted to present prices would bring the figure to £20 2s. 7d. per annum.

	£	s.	d.
Additional—	20	2	7
Medical expenses	0	10	0
Tools	1	5	0
Extra issues	0	5	0
Average four days' labour lost a year	0	4	0
Total	22	6	7

Allowing for Sundays, this cost would amount to 1s. 5d. a working day. It would seem that even if the issues were similar to those in New Guinea, the "all in" costs would be £18 + £3 (extra wages) = £21 per annum or 1s. 4d. a day. The extras allowed for and the generally shorter contracts would make the labour costs higher unless cheap native foods and recruits are available. If the labour in New Guinea can be taught to tap rubber as efficiently as the Papuan labour, then the cost of production in the Mandated Territory should be cheaper than in Papua.

Labour Conditions—Papua.

One plantation manager in Papua made the following remarks on the labour conditions and cost of production in Papua:—

> Costs of production in Papua are necessarily much higher than in Ceylon and the Federated Malay States.
>
> In Malaya, apparently, during the reign of low prices, estates have been in a position to give contracts for tapping and upkeep to Chinese at a very low figure; the Chinese, not owning the land in Malaya, has had to exist or be repatriated, and, therefore, has been forced to accept a wage which gives him a bare existence. Any increase in the price of rubber will bring into tapping a large area now not in production, with a consequent demand for labour which will carry with it restoration, to a certain extent, of former wages, and thus an increase in cost of production.
>
> In Papua, the native is always a landowner, and to exist it is not necessary for him to hire out his services, and, therefore, he is not forced to accept a lower wage, and expects the same wage now as when the price of all commodities was higher.
>
> Also, at this stage of his existence, it is impossible to work on a system of private contracts and it is only by indenture that he can successfully be employed.
>
> An appeal to the Papuan Government to allow natives to be indentured at a lower wage was emphatically discouraged.

It is very difficult to compare labour costs in Papua and New Guinea with those prevailing in Java and Malaya. Most of the work in the two latter countries is done by contract and the labour available is compelled to work by economic pressure. This is especially the case in Java where there is such a large population. Often the Javanese family almost works as a unit in such operations as coffee-picking and rubber-tapping.

The question of relative efficiency for such operations is also involved, and, taking this into account, New Guinea labour is not so cheap as it would appear from the wages actually paid.

The Malayan rubber industry is almost dependent upon immigrant labour. The rubber plantations are organized on the lines of a predominantly south Indian force (Tamils). Out of a total labour force of 281,978, of all nationalities employed on the European-owned estates, 224,628 or 80 per cent. are Indians.

The normal wage rates were 50 cents (= 1s. 2d. sterling at par) for men, and 40 cents (= 11.2d. sterling at par) a day for women, later reduced owing to recession in the industry to 45 cents and 35 cents a day, respectively.

It costs about 50 Straits dollars (about £5 16s. sterling) to send a labourer back to India and bring him back again to Malaya, which is not much different to the cost of recruitment in New Guinea and Papua.

In Samoa and Fiji, the wages rates for Chinese contract or indentured labour for tapping rubber were previously given as 3s. a day, but for many years this type of labour has been little used and their labour industry has assumed only very small proportions.

The labour costs for coolies in Java have varied from about 15 to 20 Dutch cents per day and double that for mandoers (head boys). In contract work the coolie labourer earns more—somewhere in the vicinity of 30-35 Dutch cents. At par rates, there are 12 Dutch guilders or florins to the £1 sterling (although of recent years the exchange has been only somewhere around 7 guilders to the £1 sterling), and there are 100 cents to a guilder. Fifteen Dutch cents at par equals about 3d. sterling at par and 20 Dutch cents at par equals about 4d. sterling, 30 cents (Dutch) equals 6d. and 40 Dutch cents equals 8d., which is about the maximum wage paid.

In Java, the labourer keeps and houses himself in the neighbouring kampong or village, except where a small proportion of key workers is sometimes housed on the plantation.

The extra costs would be medical expenses which are relatively small as each plantation is compelled to contribute to a central hospital on the basis of size of the plantation. Tools are also supplied by the plantation. If it is assumed that the average wage for Java coolies is 20 cents, then these costs would not increase the wage beyond 25 cents and more likely around 22-23 Dutch cents.

It will be seen that the cost for Java labour is actually much cheaper than that paid in New Guinea. This margin is not as great in Sumatra, where the labour is often introduced from Java at a considerable cost, and housing, &c., has to be provided.

Java labour is also considerably cheaper than Malayan labour. As far as one can judge, the labour costs in New Guinea are actually cheaper than the Malayan costs, but there the question of relative efficiency in proportion to the money paid is involved. There is little doubt that clearing operations in New Guinea would be just as cheap as in Malaya and would probably compare favorably with Java. In rubber tapping, factory work and skilled work, a proportion of the labour would not be so efficient as those employed in Java and Malaya, where they are generally more advanced and have had long continued association with this class of work.

The Early History of Rubber Exploitation in the Territory of New Guinea.

One important reason for the increased interest displayed in rubber planting in New Guinea is that, on several properties here, where ordinary Para rubber, *Hevea brasiliensis*, and Assam rubber, *Ficus elastica*, were established during the German régime, the produce is now being successfully and profitably exploited and a small but valuable export carried on.

The fact that the rubber tree grows in New Guinea just as successfully as in any other tropical country has been known for many years. It is, therefore, obvious that there must be certain reasons why rubber culture has not received more attention in the Mandated Territory of New Guinea since the earliest plantations were established and these will be dealt with under separate headings.

The German Government and the various companies operating prior to Australia acquiring this country, paid considerable attention to rubber culture, but rubber planting had already come to standstill in 1911. Some large expeditions, known as the Gutta-percha and Caoutchouc (rubber) Expeditions, were financed and organized by the Caoutchouc Commission(35) of the German Colonial Economic Committee, in an attempt to locate any local plants which may be profitable rubber or gutta-percha producers. The local types of *Ficus* spp. including one creeper, *Alstonias* spp., *Palaquium* spp. (Gutta-percha), and other rubber-yielding bush trees were investigated.

In the Botanic Gardens at Rabaul, the following types of rubber were established for trial purposes: Para rubber, *Hevea brasiliensis* (on quite a large scale); Ceara rubber, *Manihot utilissima*; Panama rubber, *Castilloa elastica*; Lagos rubber, *Funtumia* (or *Kickxia*) *elastica*; the rubber creepers, *Landolphia heudelottii* A.D.C. and *Cryptostegia* spp.; *Alstonia scholaris* and finally, quite large plots of Assam rubber, *Ficus elastica*.

In several representative districts experimental rubber plantations were established on a commercial scale, but in most areas more attention was paid to Assam rubber, *Ficus elastica*, than to Para rubber, *Hevea brasiliensis*. In addition to sole plantings of rubber, mixed plantings of cacao, *Theobroma cacao*, under *Hevea* rubber were tried out in almost all districts of the Territory. Also in a few cases plantings of *Hevea* and *Castilloa* rubber were planted together in mixed culture. Other rubbers were tried out commercially in limited areas.

TABLE No. 17.—RUBBER AREAS—MANDATED TERRITORY OF NEW GUINEA.
LATE GERMAN NEW GUINEA—JANUARY, 1914.(39)
Cultivated Area.

Type of Rubber.	Bismarck Archipelago + Kieta.				Kaiser Wilhelmsland–North-East New Guinea.				Total Areas.	
	Planted.		Bearing.		Planted.		Bearing.		Planted.	Bearing.
	Hectares.	Acres.	Hectares.	Acres.	Hectares.	Acres.	Hectares.	Acres.	Hectares.	Hectares.
Ficus ..	787	1,967	467	1,152	730	1,825	629	1,572	1,517	1,096
Hevea ..	365	912	30	75	146	365	25	62	511	55
Castilloa ..	167	47	154	385	50	125	50	125	217	204
Kickxia=(*Funtumia*) ..	3	7	..	..	..	..	..	..	3	..
Totals ..	1,322	2,933	651	1,612	926	2,315	704	1,759	2,258*	1,355†

* Equals 5,248 acres. † Equals 3,371 acres.

Number of Trees.

Type of Rubber.	Bismarck Archipelago + Kieta.		Kaiser Wilhelmsland–North-East New Guinea.	
	Planted.	In Bearing.	Planted.	In Bearing.
Ficus	124,696	73,028	131,124	89,715
Hevea	142,946	8,710	49,816	6,800
Castilloa	42,503	40,633	30,324	30,324
Kickxia (= *Funtumia*) ..	4,649	..	..	..

(In January, 1914, there were 511 hectares or 1,263 acres of *Hevea* rubber planted in the Mandated Territory, of which 55 hectares or 137 acres were in bearing.)

Reference to Table No. 17 will show the areas of rubber planted at January, 1914, while Tables Nos. 18 and 23, showing the amount and value of rubber exports from this Territory to the present day, should also be examined. In German times, the largest individual rubber plantations were established near Madang on the mainland, at Kokopo and in the Bainings, in sub-districts of New Britain, on the Witu or French Islands and near Kieta, on Bougainville Island.

TABLE No. 18.—QUANTITY AND VALUE OF RUBBER EXPORTS—MANDATED TERRITORY OF NEW GUINEA TO 1921.

Year ..	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
(*a*) ..	tons cwt. 11 3 £ 4,562	tons cwt. 20 17 £ 7,787.4	tons cwt. 17 1 £ 5,980.8	.. ..	tons cwt. 7 4 £ 1,245	.. £ 1,001	.. £ 5,542	.. £ 1,301	.. £ 1,749	.. £ 2,289	.. *
(*b*) ..	.. ..	.. ..	tons 19 £ 6,197	.. ..	.. £ 1,720	.. £ 5,304	.. £ 1,673	.. £ 1,196	.. £ 1,104	tons 29 £ 2,900	.. ..

Year ..	1906.	1907.	1908.	1909.	1910.	1911.	1912.
(*c*) ..	kgms. 948 lb. 2,133	kgms. 1,751 lb. 3,940	kgms. 5,775 lb. 12,994	kgms. 6,616 lb. 14,886	kgms. 6,320 lb. 14,220	kgms. 15,377 lb. 25,598	kgms. 21,253 lb. 47,819

* Exports ceased.

(*a*) From Commonwealth Year Book, Australia, No. 14, 1921.

(*b*) From figures by Dr. Hahl (40); also quoted by Dr. Klein (41).

(*c*) Figures Verhandlungen der Kautschuk Kommission des Kolonial Wirtschaftlichen Komitees No. 1, September, 1913.

(There seems some variation in the figures submitted as to the actual exports in the period 1911–1921, so figures published by various authorities are included.)

The following translations of sections of the proceedings of the conference of the Caoutchouc (Rubber) Commission of the Colonial Economic Committee, Economic Sub-committee of the German "Colonial Society", held in Berlin in March, 1911, and September, 1913, and dealing with New Guinea, were made by Mr. D. M. Scobie of the New Guinea Administration for this article. The sections referring to the establishment of rubber stations by Dr. Schlechter and to the progress of rubber planting in New Guinea to 1913 by Dr. Preuss(3c) give a very clear idea of the intentions of the German colonists and of their progress with rubber planting:—

GUTTA-PERCHA AND CAOUTCHOUC (RUBBER) STATIONS IN NEW GUINEA.

Relating to the establishment of gutta-percha and caoutchouc stations in German New Guinea on 30th March, 1911, Dr. Schlechter, Berlin, leader of the gutta-percha and caoutchouc expedition of the Colonial Economic Committee to New Guinea reports as follows:—

> The results of the gutta-percha and caoutchouc expeditions have caused the Colonial Economic Committee to approach the question of the establishment of gutta-percha and caoutchouc stations in German New Guinea. It had been shown that it would be a slow process to interest the natives of Kaiser Wilhelmsland in exploiting bush products because these natives are by nature very indolent and maintain an unfriendly attitude to any attempts to alter their mode of living.
>
> A commencement was made in 1909 in connexion with the expedition which was still in New Guinea by obtaining new Malay instructors to proceed to direct the natives in exploiting gutta-percha and caoutchouc in such a manner that the gutta-percha and caoutchouc harvested would be purchased from the natives of the various villages. This method had stood the test of time very well, mainly because it was possible to proceed hand in hand with the introduction of a head tax which was then instituted by the Government. The natives saw that in this case, the harvesting of caoutchouc and/or gutta-percha would provide a welcome opportunity to obtain the means for paying the head tax and were, therefore, more approachable than they would have been under other circumstances. Encouraged by this success, the Colonial Economic Committee decided to continue to interest the natives in harvesting gutta-percha and caoutchouc by establishing stations which were intended to serve this particular purpose. This decision was made here at the meeting of the Committee on 22nd November, 1910, and it was possible to carry this out all the more easily because funds were available from the gutta-percha and caoutchouc expedition which would ensure that the project planned, in the first instance, for the next three years, would be carried out for the present, at any rate. In the meantime, the Colonial Economic Committee has adopted the preliminary measures which are essential and it has succeeded already in engaging two Malays who are well versed in harvesting gutta-percha and caoutchouc and will probably have arrived already in New Guinea and have commenced their work there. These gutta-percha and caoutchouc stations, two of which were planned, each being under the direction of two Malays, are intended to be temporary stations to be moved from time to time to new village districts. Their task is to instruct the natives of the various villages and then to engage with them in harvesting the gutta-percha and caoutchouc in the forests until the natives are able to undertake the work alone. In this manner, it is intended to exploit the big area gradually. In order to ensure that the work of the natives shall be profitable to them, the Colonial Economic Committee has guaranteed a purchase price of 1 mark per kilogramme (2.25 lb.) at which price the goods delivered by the natives must be purchased. The Committee has also placed at the disposal of the Imperial Government gutta-percha and caoutchouc premiums amounting to 5,000 marks for distribution amongst the natives. The buying will be done by the Government stations, except when private individuals are occupied with it, for which purpose funds have been placed at the disposal of the Government stations by the Colonial Economic Committee. In order to induce the Malays to work well they will participate in the profit in such a manner that they will receive a premium of 50 pfennigs per kilogramme of gutta-percha and caoutchouc delivered and a monthly salary of 50 marks. As it has been shown during past years, those Europeans engaged in small undertakings in the Protectorate have approached the question more and more of purchasing the gutta-percha harvested by the natives, as in that case, they could always count on an acceptable profit because the payment of

the premium to the Malays would soon be discontinued. When the exploitation of the gutta-percha and caoutchouc is directed into the right channel, it may probably assist the Protectorate not immaterially to continue to prosper well because then, of course, other products of the bush would also be exploited soon by the natives. Finally, I should also like to say a few words about the question which was mooted in November, 1910, here at the Colonial Economic Committee concerning the establishing of a gutta-percha plantation in German New Guinea. I regard it as most important that it should be established by the Government because sometime there is sure to be a great demand for gutta-percha, the production of which is on the decline. Moreover, it is also probable that a better and more profitable exploitation of such plantations may be made and that it may be possible to prove thereby that private gutta-percha plantations are payable. In such a case, it would be regrettable if Germany, when the question of the cultivation of gutta-percha is mooted should have to lag behind in comparison with other nations because perhaps there might be no possibility of procuring seed for establishing plantations as has unfortunately been the case when, during recent years, the big rubber boom became noticeable. There is no doubt that in German New Guinea at a suitable elevation, i.e., approximately between 400 to 600 metres above sea level, it would be possible to find an easily accessible, suitable place for such an undertaking which could be established without great expense with the aid of the Botanic Gardens already established in the Bismarck Archipelago. It would be sufficient if not less than an area of 10 to 20 hectares were planted on which, as at Tjikeumeuh in Java, tapping experiments could be made and which would supply the necessary seed for any further plantations.

CAOUTCHOUC (RUBBER) IN NEW GUINEA.

Professor Dr. Preuss, Director of the New Guinea Company, in September, 1913, reports as follows on the cultivation of caoutchouc (rubber) in New Guinea:—

While the low market prices, caused chiefly by over-production in the caoutchouc plantations of India, have led to an economic crisis in our East African and Kamerun colonies, New Guinea has not yet suffered from any similar economic disturbance. Certainly, the owners of the caoutchouc plantations, which are now productive, have suffered an unpleasant disappointment, and particularly those planters who planted caoutchouc up till quite recently, look to the future with anxiety and apprehension, but the low prices for caoutchouc have not succeeded in exerting any noteworthy influence on the economic life of New Guinea. The reasons for this agreeable economic phenomenon are of various kinds. Firstly, there are in New Guinea no plantation enterprises which are concerned solely or even mainly with the cultivation of caoutchouc, but everywhere the coco-nut palm constitutes the basis of the planting industry. Caoutchouc comes second, or even third, after cacao. Furthermore, the quantity of caoutchouc produced in New Guinea is very small at present.

In the year 1912, only 21¼ tons valued at approximately 170,000 marks were exported and the total quantity produced since the commencement of caoutchouc cultivation amounted to little more than 54 tons apportioned as follows:—

	Kilogrammes.
1906	948
1907	1,751
1908	5,775
1909	6,616
1910	6,320
1911	11,377
1912	21,253

The fact that New Guinea caoutchouc has hitherto always sold readily at the market because of its good quality is of great moment. This is particularly noteworthy because most of the New Guinea caoutchouc which held its own with the produce of *Hevea* was obtained from *Ficus* and *Castilloa* caoutchouc, although according to experience such medium qualities suffer much more than first-class qualities when market prices tend to fall. At the end of August, *Ficus* was sold at 4.80 marks per kilogramme, *Castilloa* at 4.65 marks in September and *Hevea* at 4.80 marks per kilogramme. These prices leave the planter a profit, although it is very small, and which, particularly in the case of *Hevea*, is reduced to a minimum because the expense of producing caoutchouc from this variety is greater than with *Ficus* and *Castilloa*. The tapping of the latter two varieties is carried out in New Guinea by native Melanesians and Papuans while for the more difficult tapping of *Hevea*, which calls for greater precision and skill, it is necessary to engage Javanese who are much more expensive than natives. A skilful Melanesian or Papuan will tap approximately one kilogramme of caoutchouc per day from mature *Ficus* trees, inclusive of scrap, and in medium *Castilloa* his daily performance will amount to 400 to 500 grammes, while a Javanese will obtain from *Hevea* trees, which are certainly still young, only 250 to 400 grammes. The exploitation of mature *Ficus* trees still proves, therefore, to be profitable in New Guinea on an emergency. The expenses in maintaining and cleaning a *Ficus* plantation are also very small and are greatly limited to regulating the aerial roots. *Castilloa* requires considerably more attention and expenses to work it than *Ficus*, and *Hevea* is also still more exacting. With regard to the caoutchouc yielded for a planted area of certain size, the *Ficus* is certainly much less satisfactory than *Hevea* and *Castilloa* for from 1 hectare of *Ficus* one can scarcely expect a yield exceeding 50 to 80 grammes of caoutchouc, but from a hectare of *Hevea* four to six times as much, or even more. On the basis of these considerations the cultivation of *Ficus* and *Castilloa*, which was most zealously carried out up to the year 1905, gradually ceased in New Guinea and attention was directed more to the cultivation of *Hevea* in accordance with the *Hevea* seed which was available. Groves of inferior *Castilloa* were even converted to *Hevea*. At present, only 175 hectares are still covered with genuine *Castilloa*. The *Ficus* plantations take up an area of 1,594 hectares and those of *Hevea* an area of 463 hectares. *Hevea* is also planted as a shade in cacao and the total number of trees is 205,300 of which, however, only 7,000 have attained the age when they can be tapped. In addition to the three varieties referred to, *Funtumia elastica* is also planted but only on an area of 12 hectares. The total area planted with caoutchouc is at present 2,245 hectares. Up to the year 1905, New Guinea, with a planted area of approximately 1,000 hectares, held the undisputed leadership in the cultivation of caoutchouc in the German colonies as compared with 300 hectares in Kamerun and 500 hectares in East Africa. Soon, however, it allowed itself to be outstripped by the two latter colonies and turned more and more to the cultivation of the coco-nut palm, the advantages and favorable prospects of which as compared with the threatened over-production of caoutchouc, were becoming increasingly apparent. Even the caoutchouc boom of 1919 only caused a temporary increase in caoutchouc cultivation. After the year 1911, however, in which the area planted increased to 2,415 hectares, a reaction became noticeable. A commencement was made to cease planting *Hevea* amongst the *Castilloa* trees and to plant coco-nut palms instead and also to replace the youngest plantations of *Hevea* with coco-nut palms. Since 1911, the area planted with caoutchouc has decreased by 169 hectares and the cultivation of caoutchouc in New Guinea has ceased.

With the object of ascertaining if gutta-percha producing plants existed in New Guinea, the German Colonial Economic Committee had, in 1902, maintained an expert, Dr. Schlechter, in New Guinea, and trees were discovered in Friedrich Wilhelm's Harbour and on the Ramu River. In 1906, a more thorough investigation was made and, on the mainland, he found gutta-percha growing over large areas. Five other varieties of rubber plants were also discovered prior to 1909.

Professor Neuhauss 1911(37) also mentions the native rubbers in old German New Guinea:—"In order to make profitable use of the wild caoutchouc creepers and gutta-percha trees and thereby simultaneously to open up a source of wealth for the natives, the Government taught the blacks how to obtain the rubber and gutta-percha. Naturally, the product is not first class, and in the case of gutta-percha is even of very low grade, yet the purpose was fulfilled. Again, the quantities obtained must always remain too insignificant to play an important part in the economic life of the country."

In 1915, in referring to the exploitation of wild products in New Guinea in the Bulletin of the Imperial Institute,(38) it was stated that the activity in the collection of rubber and gutta-percha was very small in comparison with the resources available.

In reference to plantation agriculture, Table No. 19 shows the areas of plantations established in the German Pacific Territories in 1915, and the distribution of plantations according to Territory. It will be seen that, at that time, by far the greater proportion of plantation agriculture was to be found in the islands now comprising portion of the Territory of New Guinea.

TABLE No. 19.—PARTICULARS OF PLANTATIONS—GERMAN PACIFIC POSSESSIONS, 1912.(42)

Part of Colony.	Plantations Laid Out.	Cultivated Areas.
	acres.	acres.
Bismarck Archipelago and Solomon Islands (Bougainville) ..	270,000	55,750
Kaiser Wilhelmsland	180,000	17,475
East Carolines, Marshall Islands and Nauru	6,500	3,850
West Carolines, Pelew and Marianne Islands	4,250	3,725
	460,750	80,800 (*a*, *b*)

(*a*) Represents an increase in area under cultivation of 10,408 acres over the previous year of which 7,750 acres were in the islands now comprised in the Territory of New Guinea.

(*b*) Of the total cultivated area of 80,800 acres, the coco-nut occupies 73,000 acres, leaving 7,800 acres for other plants, such as rubber (*Ficus, Castilloa, Hevea*) and cocoa, but a certain amount of rubber is also grown as a mixed cultivation with coco-nuts, the area being included in the figures quoted for the latter crop.

Table No. 20 presents a comparison of the value of rubber and gutta-percha from the various German colonies in 1912. It is obvious, that, by this time, the Government had decided to grow more rubber in the other territories and to concentrate more on copra production in New Guinea.

TABLE No. 20.—VALUE OF RUBBER AND GUTTA-PERCHA EXPORTS IN 1912 FOR ALL THE GERMAN COLONIES.

Colony.	Value.
	£
Cameroons	573,611
German East Africa	421,310
Togoland	48,787
German New Guinea	8,145
Samoa	5,538
Total	1,057,391

This information given in the Bulletin of the Imperial Institute,(42) shows that although in 1905 New Guinea had more rubber planted than in any other German colony, by 1912, the value of exports from New Guinea ranked very low compared with the African colonies and was only £3,000 more than from Samoa.

Areas Planted to Rubber—New Guinea.

The figures supplied by planters as to the amount of rubber under cultivation are unreliable and must be accepted with reservation. At the 30th June, 1937, in answer to an inquiry from the Commonwealth Government, the area under rubber cultivation was said to be 1,074 hectares. This area is likely to be more nearly accurate than the ordinary plantation statistics as the inquiries were made, to a large extent, personally.

The latest figures supplied by planters are to the 30th June, 1939, but there is no differentiation between areas planted with *Hevea* and *Ficus*. The total area planted was, according to the figures supplied, 945 hectares, divided amongst the districts as given in Table 21.

TABLE No. 21.—PLANTATION STATISTICS OF RUBBER—NEW GUINEA.

—	1938–39.	1939–40.	
		Area Planted.	Area being Tapped.
	hectares.	hectares.	hectares.
New Britain	288	300	(*a*) 113
New Ireland	20	20	..
Madang	491	511	511
Kieta	119	119	(*b*)
Morobe	25	54	20
Total Area	945	1,004	644

(*a*) Mostly being tapped now. (*b*) A greater area now in tapping.

As pointed out, the more reliable figures obtained were in 1937, and, as these were better differentiated, they are herewith included (*see* Table No. 22).

Types of Rubber Planted.—Several types of rubber including *Manihot* and *Castilloa* were originally planted in German times, but at the present time only *Hevea brasiliensis* and *Fiscus elastica* are being tapped. There is a large proportion of *Ficus elastica* in the old areas planted during the German régime.

Area now being Tapped.—The latest figures available from returns supplied, which are not strictly reliable, are that at 30th June, 1939, when the total area being tapped was 348 hectares, an area of 116 hectares was on New Britain, 212 hectares in the Madang District and 20 hectares in the Morobe District. It is certain that the full area being exploited at the present time is not included as new areas are being brought in at Kieta and on New Britain.

A comprehensive table is supplied which shows the areas planted in New Guinea as far as can be determined (*see* Table No. 22). Two columns showing the areas of *Ficus* and *Hevea* rubber in tapping at the present time are also appended. These figures are later than those above and have been estimated from the areas on estates known to be tapping rubber and not from figures supplied. It will be seen that most of the old rubber in this Territory is either being tapped or arrangements are being made to tap it. It is explained that not all of these areas are in tapping at the one time and that owners of some of the areas have only recently commenced tapping.

TABLE No. 22.—1937 RUBBER STATISTICS FOR NEW GUINEA.

Section.	Plantation.	*Ficus.*		Para (*Hevea*).		Total Area. Hectares.	Area in Bearing.		
		Trees.	Hectares.	Trees.	Hectares.		Hectares.	*Ficus.* Hectares.	*Hevea.* Hectares.
New Britain	Gire Gire	14,000	39	..	..	39	39	39	..
	Gunanur	5,600	16	487	2.3	18.3	18.3	16	2.3
	Matanatar	74,400	199.5	600	7.5	207.0	207.0	199.5	7.5
	Tobera	1,800	5	..	..	5	5	..	..
	Meto	2,300	6.5	..	..	6.5	6.5	6.5	..
	Lama	12,250	34	..	..	34	34	34	..
	Ilia	7,177	20	..	..	20	20	20	..
	New Mobisberg ..	8,640	24	..	..	24	24	24	..
	Upper Seebergh ..	9,000	25	..	..	25	25	..	..
	New Massawa	5,040	14	..	..	14	14	14	..
	Old Massawa	..	..	3,200	25	25	25	..	25
	Lassuls	12,960	36	..	..	36	36	36	..
Madang	Magaria	19,248	132	21,335	147	279	279	132	147
	Modilon	11,542	140.87	5,771	71	211.87	211.87	140.87	71
	Potsdamhafen	4,469	12.5	..	..	12.5	12.5	12.5	..
	Bogia..	..	..	..	..	10	10	10	*
	Alexishafen	..	..	..	..	3	3	3	..
Kieta	Aropa	13,157	86	14,329	94	180	180	86	94†
	Arawa	..	..	..	4	4	4	..	..
Morobe	Singawa	..	..	3,600	20	20	20	..	20
		188,583	790.37	49,322	370.8	1,174.17	1,174.17	773.37	366.8

* Type not known. † About 7,000 *Hevea* trees were ill-advisedly cut out at Aropa by the owner.

N.B.—To these areas of *Hevea* approximately 50 hectares should be added to allow for the very new areas already planted bringing the total to 420 hectares.

Anticipated Increases in Areas coming into Production.—Other than the old areas indicated, no increase in the area likely to be tapped can be expected for four-five years, when tapping is expected to commence on some recently planted areas. As indicated in an original memorandum, little increase in planting will occur here unless some guarantee is forthcoming that rubber will not fall below payable levels. It is now expected that the international situation will slow up any anticipated development until the position becomes clearer.

As to future plantings, one company had planned to plant 2,000 hectares, eventually, but the war blocked this extension. Another large company has been making continued inquiries in regard to planting out large areas and will do so if the international situation permits. The manager of a third company with extensive resources has also had rubber-planting in view and said that some form of guarantee would be a definite inducement and undoubtedly would lead to expanded rubber cultivation. Two syndicates, with plantation interests here, are interested in rubber-planting. There have been numerous inquiries from private individuals, one of whom has already cleared 600 hectares, a great part of which he would be prepared to devote to rubber-planting.

Two or three planters who are now tapping old rubber are going ahead with new plantings. One has taken up and commenced clearing 200 hectares for this purpose. Five other planters, to our knowledge, have established rubber nurseries with selected seed and are awaiting the international position to clarify before going ahead with any planting. One of these has about 2,000 trees planted from selected seed and these are flourishing; a further area is cleaned, lined and holed, to receive 20,000 trees.

It is quite evident that the activities in this Territory, as far as rubber-planting is concerned, are almost negligible and are likely to remain so unless a vigorous policy is pursued. Actual new plantings up to the present time have been comparatively small. At Keravat Demonstration Plantation, 10 hectares of selected *Hevea* have already been planted and extension of the areas to 40 hectares, at least, is proceeding. At Rabaul, selected bud-wood nurseries of 1 hectare are laid down. To the present, 30 hectares have been planted in the Bainings District. About 20 hectares have been planted at Lae and Morobe, and another 10 hectares in New Ireland by individual planters, bringing the total of new plantings up to approximately 90 hectares.

The Area in the Territory Suitable for Rubber Cultivation.—In German times, *Hevea* rubber (also *Ficus*) was established in the following districts, and, as stated previously, most of this is now being exploited:—

New Britain (Gazelle Peninsula, Bainings and Witu Islands).
Madang.
Morobe.
New Ireland.
Kieta.

It is thus certain that in all districts of New Guinea there are extensive areas suited to rubber-growing.

The Department has established test areas for breeding purposes at Rabaul and Keravat, and it is intended to establish another fairly large area at the Government Experimental Station, at Bainyik, near the Sepik River, and at the Government Station, Talasea, New Britain. More experimentation is necessary with rubber in the foothills adjoining the Sepik River, which are too far inland for coco-nut cultivation, but where there are plenty of areas available at the correct altitude for rubber cultivation. Lavongai Island possesses heavy soils which are not optimum for coco-nut cultivation and rubber culture should be feasible here. Also there are several large areas of virgin freehold country on this island, but labour would need to be recruited from the mainland to develop them.

Rubber has thrived relatively well in the deltaic areas of the Astrolabe Bay area and near the Markham River on the mainland of New Guinea where more extension is warranted and new areas are being planted there by some individual planters. There are certain areas in the valley of the Waria River, Morobe District, which should prove valuable for rubber-planting.

There are many thousands of acres of suitable land in the soils flanking the present coco-nut plantations in New Ireland. Here only a comparatively narrow strip of foreshore is suited to coco-nuts. The heavier soil areas where coco-nuts do not flourish would warrant extended trials with rubber and other crops more suited to such conditions.

Rubber should thrive well in all districts of the Territory up to an altitude of 2,000 feet, where topography and other facilities permit. It cannot be stressed too much that more experimentation is necessary to determine the most suitable areas for rubber in this Territory.

At a conservative estimate there is an area of, at least, 10,000 hectares available on the remaining virgin country of expropriated and freehold properties in the Territory without reference to leasehold areas alienated or available for alienation. The properties in view are situated in Madang, Sepik, Morobe, Bainings, Bougainville Island, Lavongai, Talasea and New Ireland. Judging from the fact that only about 50 per cent. of the land held under freehold title in New Guinea is planted, there is probably more land available than the estimate given.

The area of leasehold land which could be devoted to rubber has not been absolutely determined as this would entail an extended survey to ascertain the areas available, which will be discussed under recommendations. In the Territory of New Guinea, it is safe to assume that there are decidedly more than 40,000 hectares, or approximately 100,000 acres, which could be devoted to rubber-planting, if the economic conditions were favorable and sufficient and suitable labour available. A great proportion of the land which could be devoted to rubber cultivation is unsuited to coco-nuts or cacao.

Particulars of Rubber Exports from New Guinea.

The information available concerning the rubber exports from New Guinea during the period 1906 to 1921 have been already tabulated in Table No. 18. Other information as to rubber exports during the German period of occupation was also given previously in the translation of the proceedings of the German Rubber Commission.

In Table No. 23, the quantities and values of copra, cocoa and rubber exports from the Territory of New Guinea from 1911 to the present time are compared, as the history of rubber-planting in this Territory during German times up to 1911 has already been presented.

TABLE No. 23.—TERRITORY OF NEW GUINEA—COPRA, COCOA AND RUBBER EXPORTS COMPARED FROM 1911 TO 1940.

Year.	Copra.		Cocoa.		Rubber.			
	Tons.	£	Tons.	£	Tons	cwt.	£	
1911	9,397	163,090	..	..	11	3	4,562	§
1912	11,428	198,338	..	..	20	17	7,787.4	
1913	14,299	302,186	138	7,571	17	1	5,980.8	
1914–15	..	..	111	7,935	..		..	
1915–16	11,062	161,119	186	9,005	7	4	1,244	
1916–17	18,582	267,277	†	10,277 (or 8,664)*	†		1,001	
1917–18	19,708	369,837	144	10,810 (or 11,159)*	†		5,542	
1918–19	14,886	244,314	112	11,901 (or 8,464)*	†		1,301	
1919–20	22,708	745,057	137	13,629 (or 15,530)*	†		1,749	
1920–21	23,735	664,045	133	9,105	29	0	2,989	‖
1921–22	25,894	474,110	152	9,465	..		..	
1922–23	34,648	619,715	83	3,734	..		..	
1923–24	34,974	686,519	70	3,603	..		..	
1924–25	39,151	815,938	135	6,944	..		..	
1925–26	45,806	1,016,930	113	6,510	..		..	
1926–27	47,613	849,852	67	3,500	..		..	
1927–28	65,285	1,176,040	73	3,859	..		..	
1928–29	60,435	933,769	72	3,816	..		..	
1929–30	63,832	864,358	84	3,074	..		..	
1930–31	62,303	716,543	88	3,074	..		..	
1931–32	59,452	618,298	82	3,060	..		..	
1932–33	59,040	543,906	65	2,292	..		..	
1933–34	62,270	283,329	98	3,479	..		..	
1934–35	56,251	361,413	95	3,479	..		..	
1935–36	66,684	761,309	127	3,810	..		..	
1936–37	76,409	1,231,309	133	6,610	..		..	
1937–38	73,716	847,734	183	4,475	4	0	242	
1938–39	73,345	727,949	235	6,580	54	0	4,050	
1939–40	59,368‡	504,627	(360)* 315	11,340	119	0	13,328	
To 30th April, 1941..	..	..	..	..	128	0	..	

* From another source.
† Not recorded.
‡ 70,583 tons produced.
§ *See* Table 18 as the statistics vary from different sources.
‖ Sixteen years no rubber exports.

It is obvious that the rubber exports from this Territory have always been of very limited economic importance compared with the copra industry. Rubber appeared in the annual exports continuously from 1906 to 1921 when the exports ceased altogether for sixteen years.

Present Exploitation.—In 1937, a small export of rubber was again commenced when old rubber grown here, chiefly *Ficus* and *Hevea,* was tapped. The quantity of rubber produced from these sources has mounted steeply under the higher prices prevailing during the war years. Four tons of rubber were exported in 1937-38 and 54 tons in 1938-39. One hundred and nineteen tons of rubber exported in 1939-40 brought £13,328 as against £11,340 for the 315 tons of cocoa exported.

The figures for rubber and cocoa production for 1941 are not yet available, although by the end of April, 1941, 128 tons of rubber had been exported. If this rate of export continues it is estimated that over 150 tons of this product will be exported by the end of the year, which, at £112 a ton, would be worth over £16,000 to New Guinea.

It might be pointed out that two years before the exploitation was actually commenced, it was urged by this Department that the old stands of rubber present here be tapped, and through neglect to do this, more than £10,000 of revenue was lost to this Territory. The stands of rubber found in various plantations had not been brought into bearing although only a limited expenditure and low cost of production would have been necessary to produce such rubber.

In the early days of the rubber-planting industry the relative values of the various rubber trees had not been determined and *Ficus, Castilloa* and other types of rubber were widely planted until about 1909. It would seem also that *Hevea* seed was in such demand that the planters in New Guinea during the early part of the German régime were unable to get supplies and some large areas were planted with Assam rubber, *Ficus elastica*, on various plantations as indicated. The rubber obtained from this species was readily marketable at that period when the greater proportion of the rubber used in industry was obtained from Brazil and other countries as a jungle product. It eventually proved to be far less satisfactory as a plantation crop than *Hevea* and extension of its culture was abandoned, though a little rubber is still obtained from it in Assam and Burma. The chief reason why this rubber was not satisfactory was because there is a resin, ranging from 4 per cent. to 20 per cent. (grows less with age), in the rubber, which, hardening in the course of time, annuls the elasticity. The trees are tapped by slashing or incision and after three months of this the trees require a rest or they will suffer badly. As a rubber yielder *Ficus elastica* is far inferior to *Hevea brasiliensis*.

When the prices for rubber increased to around 1s. per lb. owing to war demands and other causes, the Director of Agriculture was of the opinion that the areas of *Ficus* lying idle should be put to profitable use. Tapping tests and demonstrations to planters were made in a stand of *Ficus elastica* in the Botanic Gardens, Rabaul, and the samples of rubber obtained were examined and commented on by manufacturers in Australia. Payable prices were offered and circulars were despatched to all plantations where *Ficus* areas were present, outlining the market position, methods of tapping, packing, &c. The first exports were made from a plantation near Madang where a considerable area of Para rubber was also being tapped, and the rubber prepared and sold as smoked sheet. Working the two kinds of rubber in conjunction proved very profitable to this particular planter. Upon recommendation from the Department, tapping of the *Ficus* rubber has been carried out on most plantations where sufficient areas are present.

TABLE No. 24.—AREAS OF COCO-NUTS AND RUBBER UNDER CULTIVATION—PAPUA AND NEW GUINEA.

Year.	Total Areas Planted to all Crops.		Area under Rubber.		Area under Coco-nuts.	
	Papua.	Territory of New Guinea.	Papua.	Territory of New Guinea.	Papua.	Territory of New Guinea
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
1907	1,467	..	..	..	‡	..
1908	4,955	..	1,698	..	5,365	..
1909	7,740	45,064	1,886	..	6,716	39,595
1910	10,053	..	2,889	..	9,513	..
1911	15,881	58,837 64,599*	4,496	..	15,993	51,510
1912	24,707	73,317	6,256	..	21,958	55,133
1913	35,363	85,940	6,606	..	29,030	64,822
1914	42,921	84,941	6,203	5,618	32,722	76,847 (or 77,695)
1915	44,447	‡	7,671 (Para 1,277)	..	34,016	‡
1916	44,959	‡	7,760	..	34,686	‡
1917	47,319	‡	8,311	..	42,675	‡ §
1918	57,593	‡	8,598	..	43,560	133,960
1919	58,347	‡	8,363	..	46,101	‡
1920	62,162	‡	7,250	..	44,328	‡
1921–22	60,314	173,272	7,465	..	46,515	168,060*
1922–23	60,044	172,218	7,171	3,001	46,360	167,428
1923–24	60,863	179,163	7,481	..	46,797	172,374
1924–25	61,180	176,460	7,846	..	48,022	171,526
1925–26	62,981	182,118	7,728	..	50,506	174,030
1926–27	63,000	186,006	7,981	2,757	50,218	177,621
1927–28	61,370	195,530	8,212	..	49,244	187,650
1928–29	60,136	197,942	8,804	..	48,363	192,377
1929–30	59,487	200,263	9,012	..	49,072	198,043
1930–31	58,904¼	204,075	9,075½	..	47,838	204,075
1931–32	61,219	210,907	10,320	..	49,413	209,326
1932–33	59,751	222,062	8,796	..	49,305	214,290
1933–34	58,244¼	221,205	8,993	..	47,921	213,315
1934–35	59,445	230,360	8,933	..	49,032	221,338
1935–36	58,628	239,370	9,591	..	47,641	231,922
1936–37	59,945	243,364	10,270	..	48,188	233,343
1937–38	57,636	250,114	11,836	3,101*	45,207	239,869
1938–39	59,945	261,672	12,809	2,335†	44,188	255,385
1939–40	60,827	273,867	12,964	2,481†	44,527	261,676

* This is the most reliable estimate of rubber area in recent years.
† Incomplete.
‡ Not available.
§ Period of military occupation. Figures incomplete.

N.B.—The acreage figures for Papua are incomplete and usually represent areas taken up for cultivation—not under cultivation. Those from the Territory of New Guinea are from figures supplied by planters and are for areas under cultivation.

There have been some inquiries as to whether collection of bush rubber would be practicable at the present time. It is known that the identification of various species of *Ficus* has not been wholly clarified by botanists, as far as New Guinea is concerned, nor have all of them been tested as to quality of latex. Most of the species of *Ficus* yield latex, but the majority have a much higher resin than rubber content; in fact, some of them contain very little true rubber at all.

As stated before, there are two vines, one a *Ficus* species and the other an *Apocynaceous* vine, *Landolphia* spp., which are present in New Guinea and yield a good-quality latex. It is extremely doubtful whether they are present in sufficient quantity to make commercial rubber collection possible. Collecting rubber from bush *Ficus* would not pay unless large stands of such rubber-yielding trees are available. It is just possible that it would pay the bush natives to collect bush rubber under supervision, but it would be necessary to provide a collecting depot and packing shed.

The market for *Ficus* rubber, at June, 1941, is becoming much more limited and certain firms are not buying it at all. This, apparently, indicates that rubber supplies to America and elsewhere are being fulfilled, though the price of Para rubber still remains above 1s. per lb. This makes it certain that the exploitation of *Ficus* rubber is only likely to be a temporary phase in New Guinea.

The Average Yield a Hectare.—Owing to irregular methods of planting and loss of stand in the old plantings, it is extremely difficult to give a reliable figure for this item as far as New Guinea is concerned. The old areas under *Hevea brasiliensis* in New Guinea should give about 950–1,000 lb. a hectare (300 to 400 lb. an acre) where the trees are in fairly good condition. The average yield in Papua is about 1,050 lb. a hectare. The yields from *Fiscus elastica*—Assam rubber—are very variable, but would probably range from 3–5 lb. and occasionally up to 10 lb. a tree and here there are usually 150 trees a hectare planted (say, 400–800 lb. a hectare). When tapping *Ficus elastica* heavy yields may be harvested for a good period, then whole areas will need resting during cessation of flow. Several areas have already had to cease tapping for extended periods owing to this cause.

It is not intended that the extension of *Ficus elastica* planting should be carried out as this tree is not nearly equal to *Hevea* for planting as a plantation culture. *Ficus* culture is only of importance as far as present exploitation is concerned and is dealt with under that heading.

Hevea brasiliensis is the only rubber tree which can be recommended for any future plantings here, hence, the main objective is to determine the prospects and possibilities of this crop.

A comparison of the areas under coco-nuts and devoted to rubber in Papua and New Guinea and the extension of areas devoted to these crops from 1907 to 1939-40 is presented in Table 24. Owing to the different régimes and types of administrative control in the history of the Mandated Territory of New Guinea, many of the figures for areas under crop are incomplete. During the period of German occupation fairly reliable statistics were kept until the first world war started in 1914. During the period of military occupation here, very few complete acreage statistics were kept.

Under civil administration, since 1921, statistics have been kept regularly, but, owing to lack of any compulsion to send in proper returns, the acreage figures are only approximate, in most years.

In Papua, acreage under crops is not recorded at all so the figures given only represent areas "taken up" for cultivation of various crops each year. Allowing for this situation, the total area under cultivation in New Guinea is much greater than in Papua and the disparity has been increasing.

In 1912, the total area under cultivation in Papua was about 25,000 acres compared with approximately 73,000 acres in New Guinea. By 1924, the comparison was 60,000 acres (or roughly three times as much) in Papua as against 180,000 acres in New Guinea; by 1934, there was practically no increase in the planted areas in Papua, while in New Guinea, the acreage had increased to 239,000 acres (or approximately four times as much). Up to 1940, this ratio of increase had not changed very appreciably though there was about a 30,000-acre increase in total acreage planted in New Guinea and comparatively little in Papua.

The difference, however, in distribution of crop acreage between the two Territories is very great. It is readily seen that most of the planted area in New Guinea is devoted to coco-nuts, e.g., 240,000 acres out of a total of approximately 250,000 acres were devoted to coco-nuts in 1937-38 or, roughly, 96 per cent. of the total planted area. Roughly the same ratio can be seen for the other years tabulated. No greater argument could be put forward as to the necessity for diversified agriculture in this country instead of putting all our resources and trust in one crop. The table shows very clearly how the area under coco-nuts has increased in New Guinea. In 1909, the area under coco-nuts was approximately 40,000 acres and this increased to 77,000 acres by 1914. By 1925-26, the area had further jumped to 174,000 acres and then increased to over 200,000 acres in 1930, while now, ten years later, the area is over 260,000 acres.

Since about 1917, the area under coco-nuts in Papua has increased to a relatively small extent, though there was a considerable increase from 1910 to 1917, cf., 10,000 acres in 1910, approximately, with 43,000 acres in 1917. From 1930 to 1940, the planting of coco-nuts in Papua has been practically at a standstill, if reliance can be placed in the figures given.

In the first part of this article (*New Guinea Agricultural Gazette,* Vol. 7, No. 3) particulars of the rubber areas in cultivation and in tapping in Papua have been discussed (*see* Table No. 3). To compare the planting position with that in New Guinea, the following summarized facts are again mentioned. In Papua, 3,808 acres of rubber, as compared with 7,740 acres total area planted with all crops, or nearly 50 per cent., was devoted to rubber. By 1912-13, the total area under cultivation had increased to over 35,000 acres of which 6,275 acres (equal to 19 per cent.) was under rubber. It will be seen that, in common with New Guinea at that period, more interest was being centred on coco-nuts. From 1919 to 1929 the acreage under rubber remained around 7,250 acres, and, owing to the low state of the rubber market, very little new planting was done.

About 1930, the area of rubber was increased to 9,000 acres, with a further increase to 13,000 acres planted in 1940. This latter figure would tend to show that about 23 per cent. of the planted area in Papua is devoted to rubber. Besides these figures the 3,000 acres approximately of old rubber present in the Mandated Territory of New Guinea make a very poor showing; this is especially emphasized when it is pointed out that a great proportion of this area is devoted to *Ficus elastica* (there are roughly 800 hectares of *Ficus* and 400 hectares of *Hevea* present), and that since January, 1941, the area of old rubber present has been reduced by over 2,000 acres, due to dying off, cutting out, &c. It seems that there must be decided economic reasons for this disparity between the attention devoted to rubber-planting in Papua and the almost total neglect of this crop in the Territory of New Guinea. What are, probably, just as important factors are the lack of enterprise and knowledge of rubber-planting on the part of the companies and planters in this Territory as compared with the planters who have had long experience with the crop in Papua. This subject will receive separate attention when the economic possibilities of the crop are discussed.

It has been pointed out previously, that, in the Mandated Territory, by far the greater proportion of the plantation agriculture is found on islands where the soils are geologically newer. In Papua, the greater proportion of the agricultural development is on the mainland and rubber appears to be the most suitable crop for the older soils found there.

The relative acreage on the mainland of New Guinea on the Mandated Territory side would change considerably if the inland plateau approaching Mount Hagen and the Ramu was developed to cultivate highland crops such as coffee, rubber and other suitable cultures.

It would appear that good-production soils are nothing like so plentiful in Papua as in the Mandated Territory, and, because large areas for producing coco-nuts were not available, this largely turned their attention to rubber. It is certain that there are decidedly greater areas available for development of rubber culture on the newer and richer soils found in the Bismarck Archipelago, Bougainville Island and other islands at present than on the New Guinea mainland. It would be desirable, however, from the territorial point of view, to see rubber-growing started on the heavier soils of the mainland, where coco-nuts do not flourish and rubber grows well. It must be decided whether the economic factors are favorable to rubber production. It was, apparently, similar reasoning which caused the German New Guinea Company to plant out larger areas of rubber on the heavier estuarine deposits around Astrolabe Bay and near Madang.

Future Instalments.

The individual coco-nut planters, and the copra industry generally, have been greatly affected by the war position. It is, however, obvious that, at the present time, there are few funds available for further plantation development, nor does it seem that the present time is opportune to commence large-scale planting. Nevertheless, there have been numerous inquiries received in this Department as to the possibilities of rubber-planting in New Guinea; these inquiries are mainly received from planters who are tapping their old rubber stands at present. In view of this, it is considered advisable that further correlated information as to the economic prospects, cultural particulars, the position of the rubber industry in other countries, and possibilities of replacement by synthetics, should be made available to local planters.

In a partly developed country like New Guinea, the economic prospects of the various crops require elucidating before definite recommendations can be given as to what crops are worthy of large-scale cultivation.

The Department has been closely investigating the possibilities of this crop for some years. The Director has indicated on several previous occasions that certain provisos existed before rubber cultivation could be unhesitatingly recommended for this Territory. It was pointed out, however, that these difficulties were not altogether insuperable. The probability that rubber was being over-produced in certain countries, and that, prior to the war, heavy restrictions made relatively high prices possible, were among the threatening circumstances present. The fact that high-yielding planting material is not yet available is another handicap in this country.

It is certain that war requirements and the extra demands of highly mechanized armies are largely responsible for the present payable world prices obtaining.

In future instalments of this article, it is intended to present the various cultural and economic aspects of the rubber industry as indicated.

In normal times, the area under cultivation for all crops, and, consequently the labour force required, are much greater in the Territory of New Guinea than in Papua. Papua has, however, increased the area under rubber while there has been little parallel development in the Mandated Territory. The plantations in the latter Territory are predominantly devoted to coco-nuts and the areas under cacao, and to a lesser extent coffee, are now being increased while rubber-planting is very limited.

The value of all agricultural exports from the Mandated Territory usually ranges between £800,000 to £1,300,000, while those from Papua have seldom exceeded £375,000.

The price of rubber and returns from the product have greatly benefited Papua at a period when it has only been possible to ship a proportion of the copra from either Territory, owing to the war and shipping position. The copra was utilized on the world's markets, whereas the main outlet for Papuan rubber is in Australia.

The economic position of the Territory is not now being maintained by agricultural produce. The quantity and value of gold produced has been the main factor in this, e.g., 238,000 ounces valued at £A2,193,438 in 1939, while the value of gold exported from this Territory during the period of May, 1921, to June, 1939, was valued at £A13,500,000. The increasing quantities of timber exported (chiefly New Guinea walnut, *Dracontomelum mangniferum*), and also the increase in quantity and value of cacao exports have greatly helped the position.

EMERGENCY RUBBER COAGULANTS.*

The following notes are issued in view of the prevailing shortage of formic and acetic acids among small users. It is recommended that proprietary coagulants of unknown composition should be carefully scrutinized in relation to their coagulating power. For comparison it may be mentioned that the cost of coagulation with formic and acetic acids at the present controlled prices amounts to approximately 0.4 cents per pound of rubber.

Economical Use of Coagulants.

Under normal conditions it is recommended that the dose of acid used for coagulation should be such that a clear or only slightly cloudy serum remains. This dosage should not be exceeded and it may be justifiable under present circumstances to eke out supplies by reducing the quantity slightly. It should, however, be noted that the presence of a milky serum indicates that rubber is being lost.

Many small producers roll their rubber within a few hours of addition of acid to the latex. The amount can be reduced by approximately one-third if the latex is allowed to coagulate overnight.

It has been suggested from Malaya that economy can be effected by re-using a proportion of the serum. Tests of this method are being carried out at Dartonfield, but the results so far have been rather conflicting. In an initial trial moderately good coagulation was obtained when latex (previously diluted to a dry rubber content of 2¼ lb. per gallon) was treated with half its bulk of serum from the previous day's coagulation and the dose of acid was reduced to two-thirds of the normal quantity. In a later trial under similar conditions coagulation was incomplete even when three-quarters of the normal dose of acid was used, but a further trial now in progress is giving satisfactory results with two-thirds of the normal dose. It seems possible that the value of the method is affected by weather conditions. It can, however, be recommended for trial on estates.

Alternative Coagulants.

SULPHURIC ACID.

Rubber manufacturers object to the use of sulphuric acid as a coagulant because the presence of an excess of acid in the rubber, which may easily occur under estate conditions, has an adverse effect on its vulcanizing properties. Nevertheless, sulphuric acid can be regarded as a reasonably satisfactory emergency coagulant, and it is, in fact, the only alternative material which is likely to be obtainable in adequate quantities for estate use at short notice.

Concentrated sulphuric acid (oil of vitriol) is extremely dangerous to handle and should be diluted to half-strength before issue to estates and retailers. The half-strength acid should be diluted before use as a coagulant in the proportion of one part of acid to 80 parts of water. *Dilution should be effected by adding the acid slowly to the water and not by adding water to the acid.* Approximately ½ pint of diluted acid is required to coagulate a rubber sheet weighing 1½ lb. (8 fluid oz. of half-strength acid in 4 gallons of water per 100 lb. of dry rubber).

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* From the *Tropical Agriculturist*, Volume XCIII., Number 6, page 348.

The following points should be carefully noted when using sulphuric acid:—

(1) The quantity used for coagulation should be as small as possible. A slightly cloudy serum should remain after coagulation.

(2) The rubber must be thoroughly washed during and after milling to remove surplus acid. The latex should be diluted to a rubber content not exceeding 1½ lb. per gallon.

(3) Machinery is liable to be damaged by the diluted acid unless thoroughly washed after use.

Half-strength sulphuric acid is at present being supplied by a leading importer at Rs. 2 per gallon (exclusive of the cost of carboys). One gallon should suffice for the coagulation of approximately 2,000 lb. of dry rubber.

VINEGAR.

Vinegar is a useful emergency coagulant but it is not likely to be available in large quantities. Toddy vinegar contains approximately 5 per cent. of acetic acid and 1 gallon will coagulate approximately 100 lb. of dry rubber. It may be used undiluted for crepe manufacture but should be diluted with an equal quantity of water for sheet making. Approximately ¼ pint of diluted vinegar is required to coagulate a rubber sheet weighing 1½ lb. Rice vinegar containing about 8 per cent. of acid is also available.

COCO-NUT.

The milky fluid which occurs in the coco-nut ferments on standing and produces an acid liquor which can be used as an emergency coagulant. The maximum acidity, corresponding to about ½ per cent. acetic acid, develops in 3-4 days, after which a reduction of acidity takes place. This material and other plant extracts referred to in a later paragraph should be strained through clean cloth before use to remove any solid matter. Approximately one " bottle " (⅙ gallon) of the fluid is required to coagulate a rubber sheet weighing 1½ lb.

PYROLIGNEOUS ACID.

Pyroligneous acid containing approximately 10 per cent. of acetic acid, together with other products, is obtained by the distillation of wood or similar material such as coco-nut shells. The practicability of preparing an improved material from coco-nut shells at an economic price is being investigated by the Coco-nut Research Scheme, in conjunction with the Department of Industries, but commercial supplies are not available at present.

SUGAR.

When undiluted latex containing a small quantity of sugar is allowed to stand overnight the sugar ferments and moderately complete coagulation occurs. This form of coagulation does not produce first-grade rubber; crepe is off-colour owing to the absence of sodium bisulphite and the sheet is " bubbly ". However, the method may be useful, especially to small holders in case of a severe shortage of coagulants.

For the preparation of a rubber sheet weighing 1½ lb., 1¼ oz. of sugar (half match box full), dissolved in ¼ pint of water, should be added to ½ gallon of undiluted latex. (One pound of sugar in 2 gallons of water per 100 lb. of dry rubber.)

OTHER COAGULANTS.

Lime juice contains 5-10 per cent. of citric acid and may prove useful as a coagulant for small holders. The juice of 3-6 limes, depending on ripeness and juiciness, is required for the coagulation of a rubber sheet weighing 1½ lb.

Various other plant juices and extracts are stated to be used by small holders when normal coagulants are unobtainable or unduly expensive. *Goraka* fruits, when extracted twice by boiling with water, were found to have an acid content of approximately 10 per cent. The extract from 1 lb. of semi-dried *goraka* fruits would thus suffice for the coagulation of 20 lb. of rubber. *Weera* and *kamaranga* fruits also yield acid extracts.

No great objection can be raised to the use of such products in an emergency, but vinegar or coco-nut water are considered preferable.

Under the present exceptional conditions it may be necessary as a temporary measure for some producers to vary their normal methods of coagulation. *It is, however, very strongly urged that normal procedure should be resumed at the earliest possible moment with a view to maintaining the Island's reputation for producing good-quality plantation rubber.*

THE TROPICAL GRASS, "MELINIS MINUTIFLORA", AS A PREVENTATIVE AGAINST MALARIA AND OTHER TROPICAL DISEASES.

It is recommended that Gordura grass, *Melinis minutiflora,* should be planted around all dwelling-houses in Venezuela, as a protection against malaria and tick-borne diseases of animals, as mosquitoes are almost completely absent from pastures planted with this grass as long as it is in the green stage, and cattle covered with ticks when entering such pastures become free after a few weeks. The grass, which is rich in protein, and, therefore, is extensively planted for fattening animals, is rather coarse for sheep, but suitable for cattle, horses and mules. Although generally used for pasture it can also be cut for fodder. It cannot be grown on swampy ground, but thrives on arid soil. It has a peculiar penetrating odour and contains an oily substance, which probably accounts for its "anti-verminous" effects. At the height of the dry season, on exceptionally arid soil, the stems may get dry and a good deal of the oily contents disappears, in which case some pests, particularly ticks, may be found in the pasture.—(*Extract from "The Review of Applied Entomology", December,* 1940.)

THE COPRA INDUSTRY.

By R. C. Hutchinson.

Department of Agriculture, Rabaul.

Part II.

In the first part of this article, a scheme for the sounder establishment of the copra industry was briefly outlined. The basis of the scheme was—

1. (1) The local extraction of coco-nut oil, employing the most up-to-date methods and machinery.
2. (2) The sale of all oil which cannot be sold for the manufacture of margarine and soap as a cheap liquid fuel, a suitable denaturant having first been added.

The most important advantages of extracting oil locally were enumerated and the most popular methods of extraction briefly discussed.

The practice of sending copra overseas to have the oil extracted is unsound, and, although the arrangement may seem satisfactory when the price of copra is high, its weakness is most evident when the price is low. When the copra situation first became critical, the question arose as to whether copra might not, with advantage, be treated locally. This suggestion met with strong opposition from firms with oil-milling interests in Australia and elsewhere, not because it was unsound, but because it would mean a re-arrangement of the organizations of these firms. There are two important disadvantages to the local extraction of oil which are as follows: Firstly, in many countries, the duty on imported coco-nut oil is higher than on the oil imported as copra. Secondly, to the cost of refined oil and perhaps crude oil, would have to be added the cost of drums, barrels or other containers. According to the author's scheme, however, the bulk of the oil exported would be either crude oil, which could be exported in bulk if suitable ships were available, or refined hardened oil, which could be exported in a semi-solid condition. In any case, these additional costs would be partly, if not wholly, compensated for by a reduction in freight due to decreased weight and volume.

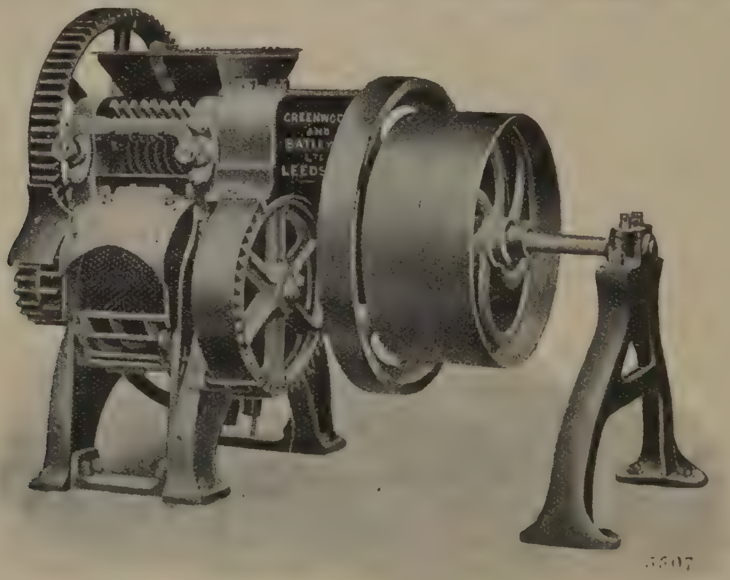
To illustrate the unsoundness of sending copra overseas for treatment, consider the position if a primary industry in Australia were conducted along similar lines. The dairy industry affords, perhaps, the best illustration although the cases are not exactly parallel.

Each year Australia sends large quantities of butter overseas. Instead of exporting this butter in the form of butter fat, consider the position if Australia were to export the raw material (milk) from which the butter is extracted and if the extraction of the butter fat were conducted overseas. The raw material from which the butter fat is to be extracted could not be exported as such and it would first be necessary to dry the milk which would then be in the form of whole milk powder. If this powder were shipped in sacks, the butter fat would deteriorate considerably, and to ship it in containers, which would prevent deterioration, would be expensive. On reaching its destination, the butter fat would have to be extracted from the dried milk. This would be more difficult than when the milk was in its fresh state and the quality of the butter fat would be lower. The remaining portion of the milk powder, which contains all the nitrogen and mineral matter, would not be returned to Australia, so that there would be a definite improverishment of Australian soils.

Could the dairying industry in Australia be successfully conducted under such conditions? Could the industry stand the additional expense of drying the milk for exportation? Could it afford to pay the extra freight and packing costs of exporting the whole of the solid matter in milk instead of only the butter fat? Could the dairy-farmer afford to receive a lower price for his butter which would be inferior to that produced from fresh milk? Could he afford to lose his skimmed milk, which, apart from being an excellent feed, eventually returns to the soil, generally in the form of dung, most of the mineral matter taken from it? The answer to these questions is definitely "No". Why, then, should so much be expected of the copra industry?

Oil Extraction by the Solvent Process.

The oil-extraction process most suitable for this Territory is that which can handle fresh meat as well as copra. Plantations in the neighbourhood of extraction mills could then send fresh meat for treatment, but on plantations in remote localities copra would still have to be made. On other plantations, not in the neighbourhood of extraction mills but connected to them by road or a regular and frequent shipping service, partially dried meat would probably suffice. Eventually, as transport facilities improve, the amount of copra made would decrease and the amount of fresh meat treated increase. In the first part of this article, five processes were mentioned for the extraction of coco-nut oil and it was stated that the solvent and bacterial processes could treat both fresh meat and copra. Recently, another process was developed for the extraction of oil from fresh meat. This is called the "Lava" process and is described in another article in this issue.



Copra Reduction Mill.

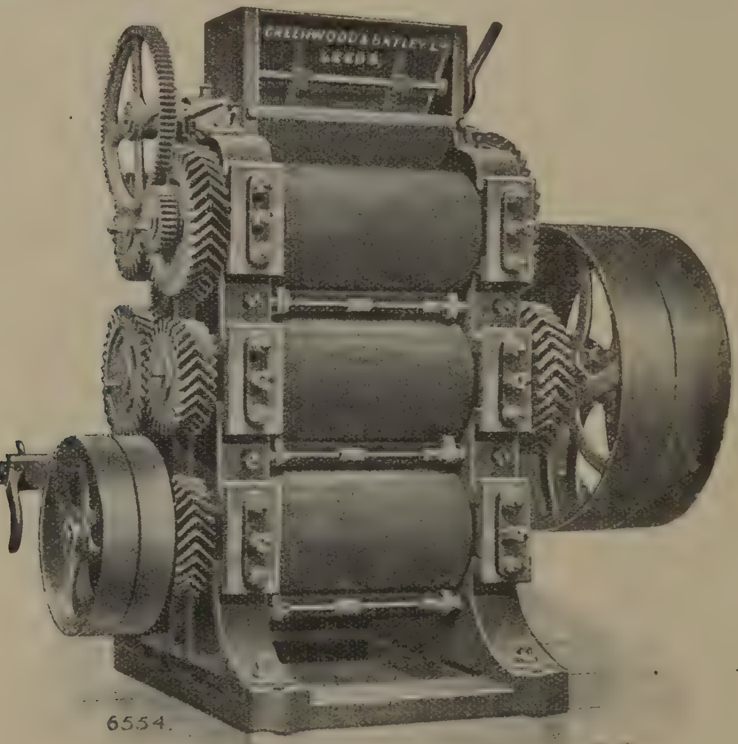
The solvent extraction process was first introduced in 1843, by Fisher of Birmingham, but it is only in recent years that the process has been extensively adopted for it has had to struggle against the prejudices inherited from its earlier and admittedly imperfect working. In brief, the process consists of allowing some such solvent as benzene, ether, chloroform, carbon disulphide or carbon tetrachloride to percolate through the disintegrated copra in a closed vessel, heated or cold, of draining off the solvent and the oil which it has dissolved from the copra meal, of transferring the liquid to a heated still, and of then driving off the volatile solvent so as to leave the oil behind. The solvent driven off is condensed and used repeatedly. So far as the percentage of oil recovered from the copra is concerned, this process is distinctly superior to the pressure process, for by it over 99 per cent. of the oil can readily be extracted from the copra, whereas the pressure process extracts only 90–95 per cent. of the oil. A further advantage of the process undoubtedly lies in the simplicity and cheapness of the plant required as compared with that used under the pressure method.

It has been argued that the solvent process extracts the oil so effectively that the copra meal is almost useless as a cattle feed. In refutation of this objection it may be stated that, both in England and America, large quantities of meals manufactured by the solvent process are being used daily as cattle feed. Whether the entire absence of oil in meal lowers its value as a foodstuff is a very debatable point. There are distinct indications that a marked percentage of oil in a cattle food is not such an advantage as it was at one time believed. The oil is mostly a heat-forming substance which can be largely replaced by carbohydrate. It is the protein in the meal which is of value from the food or flesh forming point of view, particularly in the tropics where pastures are low in protein, and solvent extracted meal is richer in both protein and carbohydrate than meal manufactured by the pressure process. The fact that oil cakes, manufactured by the pressure process, cannot be fed to cattle undiluted, but only when mixed with bran or some such substance, indicates that they are a richer food than they need be. In any case, the argument against the solvent process, which is based on the deficiency of oil in the residue, entirely falls to the ground when it is remembered that, under modern conditions, the operator controlling this process can arrange to leave as much or as little oil in the residue as he may desire.

It is now well established that grease or oil in a fertilizer prevents it being absorbed by the soil, for, if present, it acts to defend the fertilizer against water and the attacks of those organisms which convert the constituents of the fertilizer into immediate soil foods. Clearly, then, the solvent process, eliminating, as it can be made to do, practically all oil from the residue, has very good claims to attention when the residue is to be used as a fertilizer. It is the author's opinion that all copra meal produced in the Territory should remain here and be used as a fertilizer. This may be done by returning the meal directly to the soil, or, less efficiently, by feeding it to plantation cattle. Should it ever be more economical to export the cake and import artificial fertilizers to return to the soil the mineral constituents exported in the cake, then this may be done, but it is unlikely that such a state of affairs will arise for many years.

It has been stated that it is difficult or impossible entirely to eliminate all trace of the solvent from the oil and meal so that the oil is unfit for edible purposes, while the nauseous taste or poisonous action of the solvent left in the meal provides a second reason why such meal should not be fed to cattle. In confutation of this objection it may be stated that in England and America there is a number of large plants, employing the solvent extraction process which produces nothing but oil of edible quality used in the manufacture of margarine and meal which is used as a cattle feed.

Location and Size of Proposed New Guinea Plant.—Before the war, New Guinea exported nearly 75,000 tons of copra per annum and in ten years' time, according to an equation previously obtained (*see* this Gazette, Vol. 7, No. 1, p. 39), she will probably be exporting approximately 100,000 tons per annum. This copra comes from all parts of the Territory except the inland areas of the larger islands. It is generally bagged on the plantation and shipped by schooners or small inter-island ships to five main ports where it is inspected, graded and collected by overseas ships.



Horizontal Reduction Mill, with three pairs of fluted rollers 15 inches diameter x 27 inches long.

The question now arises as to whether it would be better to erect a number of small extraction plants in different parts of the Territory or one large plant at some central point. It has been suggested that a factory ship, which could call at the different plantations, collect copra, treat it and take it overseas would be best. This idea, however, can be ruled out. No matter what method of extraction is employed, it is, definitely, not a feasible proposition as any one who has studied the nature of the plant required will agree. The concentration of all copra at one central point would involve a lot of long-distance inter-island shipping which would be expensive and the number of planters within the neighbourhood of the mill who could submit fresh meat for treatment would be very small, also, there would be difficulty in providing such a large factory with sufficient water in the dry season.

In the author's opinion, the most suitable arrangement would be the erection of five unit-mills each capable of treating one-sixth of what New Guinea's copra or fresh meat production will probably be in ten years' time (namely, 100,000 ÷ 6 tons). Initially, three of these mills could be erected at Madang, Kavieng, Buka and two adjoining each other just outside Rabaul. These mills, working continuously, would be able to handle all New Guinea's copra, plus a considerable amount of fresh meat for the time being. Later, when the pressure on these mills increased it could be relieved by erecting a sixth unit-mill either in another district or adjoining one of the existing mills. The location of the sixth mill could be best decided after the other mills had been in operation for some time.

We will consider as our unit-mill then, a mill capable of treating one-sixth of New Guinea's copra production ten years hence, that is, 16,700 tons of copra per annum or approximately 48 tons of copra a day of 24 hours.

Process Requirements.—Oil extraction by the solvent process is carried out in two distinct steps—first the milling of the raw material and then the extraction using a solvent. In the following specifications the milling plant is manufactured by Messrs. Greenwood and Batley, Ltd., Albion Works, Leeds, and the extraction plant is a standard four-pot solvent extraction plant manufactured by George Scott and Son (London) Ltd., Artillery House, Artillery Row, London, S.W.1.

There are two special features of the "Scott" extraction plant. In the first place, the extraction is performed in the cold, thereby practically eliminating all danger arising from the inflammable nature of the solvent used. Secondly, the extraction is effected partly by the solvent in liquid form and partly by it in the form of vapour. In this respect, the system differs from others. In general, the solvent is wholly in the form of a liquid, although it is evident that when hot extraction is adopted, the solvent admitted as a liquid must at least in part become vaporized. The "Scott" system, therefore, may be said to combine the advantages of hot extraction with the safety of cold extraction.

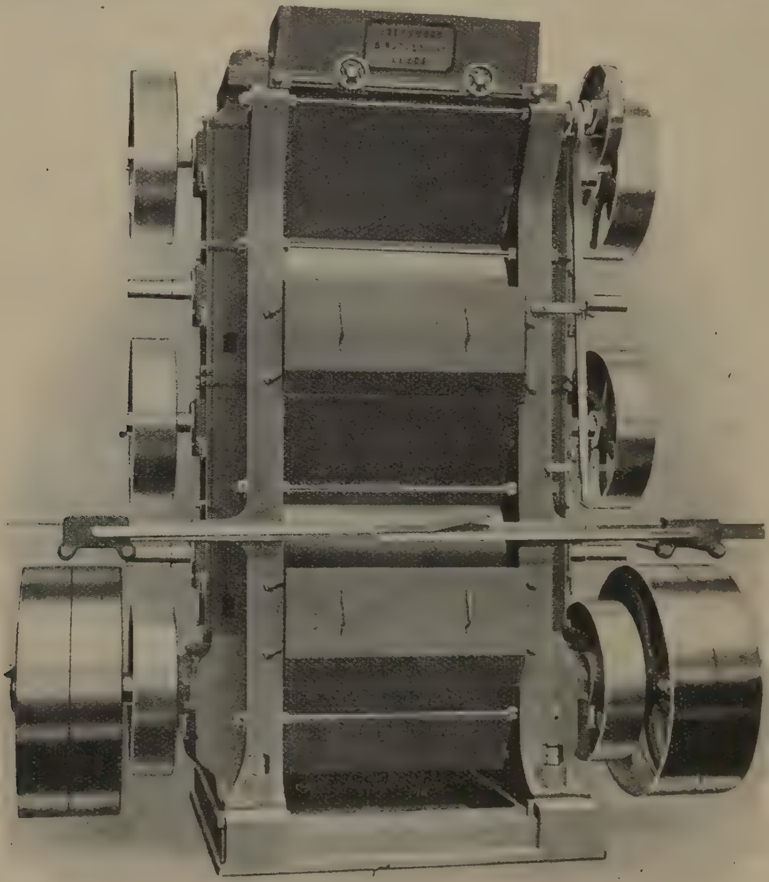
The extraction plant about to be described is designed to deal with practically any suitably milled oil seeds, nuts or kernels. It permits the use of any well-known solvent, but a petroleum benzine with a distilling range between 75°-95° C. would probably be best. The loss of solvent in this process does not exceed 1½ per cent. calculated on the material charged into the extraction plant.

The water requirements for the extraction plant and condensers would be approximately 6,000 gallons per hour. This water should be as cold as possible.

Dry steam at a pressure of not less than 80 lb. per square inch will be required. The consumption of fuel in the process based on a boiler efficiency of 8 : 1 will average between 3-4 cwt. of coal per ton of material treated. However, it would probably be desirable to burn crude oil instead of coal so that when the price of coco-nut oil is low, crude coco-nut oil could replace imported crude mineral oil.

A single unit plant can be operated by four men per shift. One man would be required to have a knowledge of chemical engineering, but Asiatics or natives could be trained for the other positions. The handling of the raw material before treatment and the removal of the meal discharged from the extractors could be done by unskilled native labour. Where two-unit plants are adjoining almost the same staff could run both plants.

The extracted meal will be free from all traces of solvent but will contain 15-18 per cent. moisture which, if desired, may be reduced in a suitable dryer.



Set of Five-high Seed Crushing Rolls, 24 inches diameter x 42 inches long.

Arrangement of Plant.—The arrangement of the milling plant in relation to the extraction plant to a large extent depends upon any building which might be available. If buildings exist, and if these permit of the milling plant being located directly above the extraction plant, this is a desirable and advantageous arrangement. On the other hand, where existing buildings do not permit of this, other arrangements are possible by introducing the use of suitable elevators. It is at all times desirable that consideration be given to minimizing the amount of labour involved in the handling of the material in process.

Specifications and Cost of Milling Plant.—The price quoted for the milling plant specified below was £5,084 sterling net in March, 1941. This price has probably changed slightly since then—

MAGNETIC SEPARATOR.

One rapid electro-magnetic drum 16 inches diameter by 12 inches wide, comprising a very powerful special shaped electric magnetic unit, built of best-quality steel and wound with copper wire, the whole unit being mounted on a shaft having fixed bearing brackets and arranged for radial adjustment externally by means of a tommy bar at the end of the shaft protruding from the bearing bracket. The drum is totally enclosed, and fitted with dust-proof cover, complete with pulley and all necessary fittings. It would be wound suitable for any D.C. voltage available up to 250. The horse-power required to drive the separator is about half horse-power. Control switches fitted with pilot lamp for the shunt break are included.

MILLING PLANT.

The milling plant for treating copra would comprise—

Two primary reduction mills for copra (*see* illustration).

Two three-pair roller reduction mills with rollers 15 inches diameter by 27 inches long (*see* illustration).

Two sets of five-high Anglo rolls with rollers 24 inches diameter by 42 inches long, having an arrangement for reducing the weight of the rollers on the seed (*see* illustration).

Each preliminary reduction mill requires 15 B.H.P., each three-pair roller reduction mill 15 B.H.P., and each Anglo roll 27 B.H.P.

Specifications and Cost of Extraction Plant.—The price quoted for the solvent extraction plant quoted below was £14,500 sterling net in March, 1941. This price has also probably changed slightly since that date.

STORAGE BINS.

Four, in mild steel, of rectangular construction with conical bottoms. Welded throughout. Suitable brackets welded to pans to rest on purchaser's girders. Discharge openings fitted with slides.

EXTRACTORS.

Four, in mild steel, 6 ft. 6in. internal diameter by 7 ft. 6in. deep.

Complete with charging and discharging doors, and covers, external dust-catcher, false bottom. Each extractor fitted with substantial stirring gear; stirrers of forged steel securely keyed to central shaft. Central shaft of mild steel actuated through deep stuffing box. Central shaft fitted with machine-cut bevel wheel actuated through bevel pinion, secured in turn to countershaft. Gearing supported on cast-iron bracket secured to bottom of extractor. Countershaft fitted with fast and loose pulleys, with suitable belt-striking gear.

Extractors fitted with vapour valves, feed cocks, gauge glass fittings, air cocks, run-off cocks, safety valves and all accessories.

CONDENSERS.

One, casing and end covers in cast iron, tubeplates and 770 ¾-in. and 6 feet long tubes in brass. Both tubeplates fitted with ferrules. Necessary openings formed on casing and end covers.

WATER SEPARATOR.

One, in mild steel, 2 feet diameter by 18 feet deep. Complete with all internal and external fittings.

TANKS.

Solvent storage tank—8 feet diameter by 30 feet long.
Half-spent tank—5 feet diameter by 12 feet long.
Still-feed tank—5 feet diameter by 24 feet long.
Drainings tank—3 feet diameter by 6 feet long.

Fitted with manhole openings and covers, gauge glass fittings, and necessary openings.

SOLVENT AND MIXED OIL AND SOLVENT PUMPS.

Three, steam-driven, vertical, Worthington type. Specially designed for pumping hot and cold petroleum spirit. Valves and seats of nickel steel.

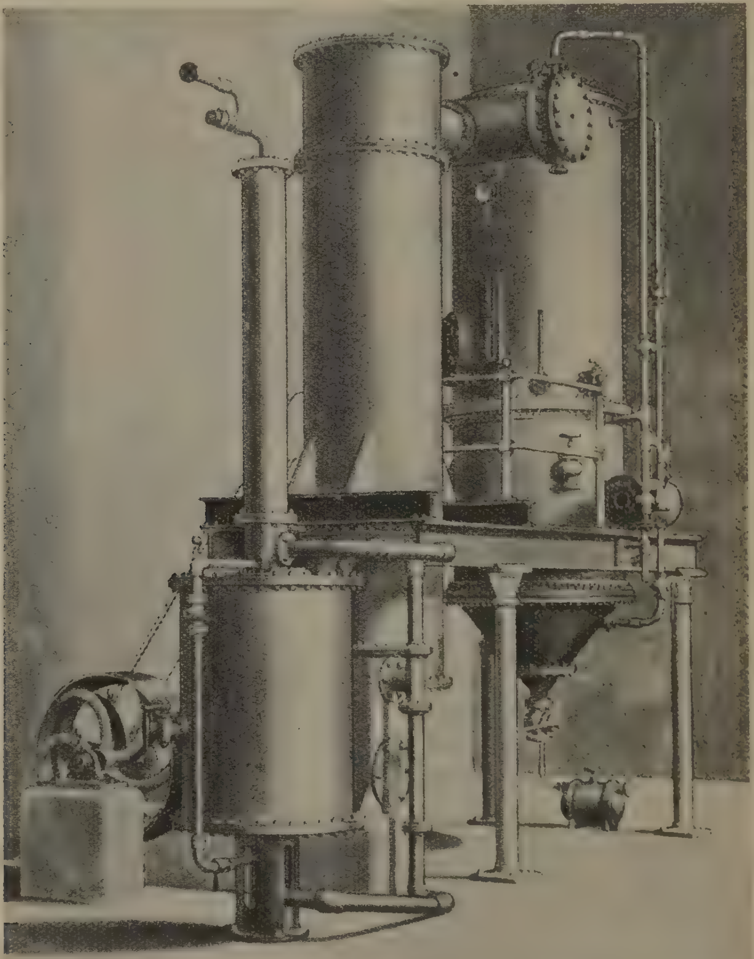
Oil pump—For delivering oil from still to storage tank, one similar pump, steam-driven.

SOLVENT HEATERS.

Two, casings and end covers in cast iron. Tubeplates and 270 ¾-in. by 6-ft. long tubes in mild steel. Tubes expanded into tubeplates. Necessary openings formed on casings and end covers.

VACUUM OIL STILL.

One, casing of calandria in mild steel, flanged and machined. Top and bottom pans and catch vessel in cast iron, flanged and machined. Tubes and tubeplates in mild steel.



Scott Patent Vacuum Still.

Still, 7 feet diameter. Calandria 4 feet deep over the tubeplates. Top pan in parallel section 6 feet deep. Dome 9 inches deep. Mounted on dome, cast-iron vapour separator or catch vessel. Casing fitted with man-hole openings and covers. Long sight and light glasses, thermometer, feed valve. Vacuum gauge and all accessories. Calandria fitted with safety valve, steam control valve and steam trap. Still fitted with open steam coil (*see* illustration).

Condenser: Attached to still, one condenser. Casing tubeplates in brass. Top and bottom tubeplates ferruled.

Vacuum pump: One vertical belt-driven air pump of the Edwards type, 17 inches diameter by 10 inches stroke. Pump actuated through gearings. Countershaft running in adjustable gun-metal bearings. Machine-cut gearing between crankshaft and countershaft, the pinion being of raw hide. Fast and loose pulleys, fitted on countershaft, with belt shifting gear. Pump gun-metal lined, pump buckets of gun-metal, pump rods of manganese bronze. Valve plates of gun-metal bolted on top of liners. Valves on Kinghorn metallic type, working on bronze studs and brass screws. Pump complete with all accessories.

ABSORBER.

Oil scrubbing column, complete with trays, still, cooler, oil tanks and circulating pump.

MEAL HOPPER.

For reception of meal from extractor. Secured to bottom of hopper, one spiral conveyor, actuated through machine-cut spur gearing. First motion shaft fitted with fast and loose pulleys, and belt-striking gear. Worm delivering extracted meal into dryer.

MEAL DRYER.

One Simon size 2A dryer. Capacity 45 cwt. meal per hour. All complete with fast and loose pulleys on machine shaft, steam trap, inlet valve and pressure gauge.

MEAL COOLER.

One, water jacketed spiral conveyor, receiving meal from dryer. Worm shaft actuated through machine-cut spur gearing, fast and loose pulleys, with belt-shifting gear.

MEAL FAN.

One, belt-driven blowing fan. Receiving meal from cooling worm. Fan connected by means of galvanized steel trunking to cyclone. Cyclone to be located in convenient position for delivering cooled meal to meal warehouse.

SHAFTING.

Contractors provide all shafting, brackets, pulleys and bearings.

SOLVENT, MIXED OIL AND SOLVENT, AND OIL PIPING.

All provided by contractors. Piping conveying oil to be connected to purchaser's oil tank in department immediately adjoining.

Cost of Buildings, &c.—The foregoing prices do not include the cost of—

Buildings,
Foundations,
Steel supports,
Platforms, stairways and handrails,
Motors and starters,
Oil tanks,
Belting,
Steam, water and drain piping,
Non-conducting composition,
Erection,
Freight and
Wharves,

the cost of which would probably be in the neighbourhood of £15,000 unless suitable buildings were already available.

Total Cost of Erecting Five Unit-mills.—The total cost of erecting a unit plant capable of treating 48 tons of copra, or its equivalent fresh meat, per day of 24 hours is approximately—

	£A.
Milling plant	6,400
Extraction plant	18,100
Buildings, &c.	15,000
Total	39,500

and the cost of five unit-mills capable of treating the whole of New Guinea copra or fresh meat would be approximately £A197,500 and the cost of six mills to complete the scheme would be £A237,000.

Production Costs.—Production costs cannot be computed accurately as the cost of solvents and fuel is continually changing. A rough indication of the cost of production is given by the following table:—

	£
Staff—	
Three supervisors at £700 per annum	3,100
Three Asiatics at £150 per annum	
Thirty natives at £18 per annum	
Amortization spread over a period of approximately 25 years ..	1,600
Solvent	5,000
Fuel	2,500
Other expenses	2,000
Total	14,200

One ton of copra then can be treated for about 16s. or a ton of oil produced for approximately 24s. This is approximately half the cost of producing oil in America by the pressure process. Hence, if copra is bought for £5 per ton, a ton of oil in the form of copra can be bought for £7 10s. and a ton of oil can be produced for approximately £8 15s. If the oil is to be exported, to this cost must be added the cost of containers, transport, handling charges, insurance and customs duty. Oil can be transported to Australia for £2 per ton although £3 is usually charged. Customs duty is 6d. per gallon or approximately £6 per ton, but this duty would probably be lifted under the circumstances which exist at the present time. If this duty were lifted oil could be landed in Australia for abount £15 per ton or £12 10s. per ton if shipped in bulk.

We will now consider briefly the position when the European markets for coco-nut oil are closed and there are only limited markets in other parts of the world. Then, according to the author's scheme, all the oil which cannot be sold for the manufacture of margarine and soap will be exported to Australia for sale as fuel. This fuel-grade oil will probably have to be sold below the cost of production but, even if this is so, it will not require the sale of much of the higher-grade oil to compensate for the loss on the fuel grade. For instance, take the cost of landing oil in Australia as £15 per ton, then the total cost of landing all New Guinea's oil (50,000 tons per annum) in Australia would be approximately £750,000. If 70 per cent. of this total oil were sold as fuel grade at £10 per ton, then the remaining oil would have to be sold for only £400,000 or £27 per ton to make the proposition pay. If the oil brings a higher price than this, then a higher price can be paid for copra.

The latter part of this paper is very brief and very approximate, but it gives sufficient information to show that, even when the copra industry is passing through a crisis such as the present, it is still possible for the industry to be carried on as a paying concern.

THE COMMERCIAL POSSIBILITY OF THE LAVA PROCESS.*

From the Standpoint of Machinery and Equipment.

By Pedro E. Torres.

Bureau of Science.

With the organization of the National Coco-nut Corporation, considerable interest is being shown in the rehabilitation of the coco-nut industry. The problem of how to get the highest possible income from the coco-nut comes foremost to the leaders of the Corporation. A general solution would be (*a*) the growing of the best-quality coco-nut through the application of modern scientific methods of agriculture, (*b*) the search for the most efficient and most economical method for the manufacture of coco-nut oil, and (*c*) the utilization of the products of coco-nut other than the meat, such as the husks, shells, &c.

At present coco-nut oil is the main product of the coco-nut industry; hence, one of the most important lines of attack on the main problem should be the search for the most economical and efficient method of producing oil from the coco-nut meat. The present commercial method used is the expeller process of producing oil from copra. This method, in spite of its high degree of mechanization and efficiency, is always beset with several disadvantages, among which are the following:—

(1) It uses copra which, in spite of the exercising of utmost care in handling and storage, always produces an oil having a large amount of free fatty acids, and is rancid and coloured, thereby requiring additional refining operations.

(2) The only by-products it produces are the copra meal and cake which are dirty and rancid, and can only be used for animal feed.

To avoid these ever-present disadvantages of the expeller process, the best way would be to use a method which produces oil directly from coco-nut meat, without the use of excessive pressure and heat. After thorough investigation of the possibilities of extracting oil directly from the fresh meat, the Lava process has been evolved. This process consists of extracting the "gata" from the fresh meat; processing the "gata" to separate the cream from the "skimmed milk" or maceration water and from the protein solids; and subsequently treating and processing the cream to break up the oil-water-protein emulsion, thereby separating the oil in its free state. How these stages were evolved is beyond the scope of this article.

In the design of a commercial plant, the two most important considerations to be followed to ensure continuity of operation are the choice of equipment and the design of the plant layout. These entail good engineering knowledge. From experience it is generally found that it is advisable to select standard equipment—which can easily be procured and replaced. With this basis in mind, it will be seen from this article that the Lava process can be worked out commercially.

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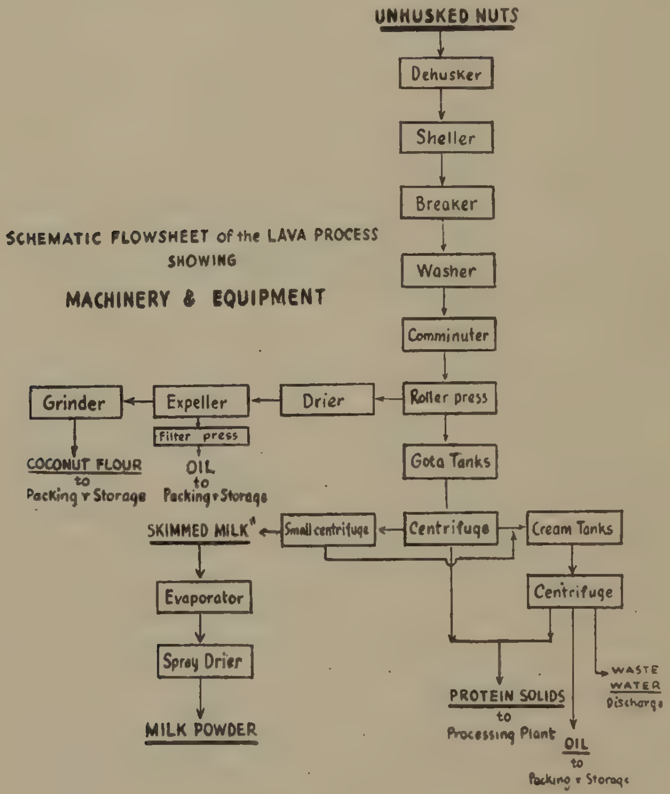
* Reprinted from *The Coconut Journal*, Volume I., No. 3, page 7.

In the accompanying figure is shown the schematic flowsheet of the Lava process showing the machinery used in the production of the coco-nut oil and the processing of the different by-products. The uses of the machinery can be summarized in the following discussion of the various steps.

Shelling.

Up to the present time there has been no efficient machinery to perform the shelling operation. This operation is rather difficult to mechanize on account of the variation in the size and shape of the nuts. Consequently, this operation is being done by manual labour. Around the coco-nut regions, especially where there are plants for the manufacture of desiccated coco-nut, there are plenty of men who are skilled in the art of shelling, so that the supply of these shellers would not be lacking during commercial operation.


SCHEMATIC FLOWSHEET of the LAVA PROCESS
SHOWING
MACHINERY & EQUIPMENT
UNHUSKED NUTS
Dehusker
Sheller
Breaker
Washer
Comminuter
Roller press
Drier
Expeller
Filter press
Grinder
COCONUT FLOUR
to
Packing & Storage
OIL
to
Packing & Storage
Gota Tanks
Centrifuge
Small centrifuge
SKIMMED MILK*
Cream Tanks
Centrifuge
Evaporator
Spray Drier
MILK POWDER
PROTEIN SOLIDS
to
Processing Plant
WASTE
WATER
Discharge
OIL
to
Packing & Storage

In connexion with the shelling operation unhusked nuts may be brought to the plant so a dehusking operation by machines and the subsequent defibring of the husks may be necessary. These operations have been thoroughly discussed in several articles of this journal so no further discussion of the machines is necessary.

Breaking.

The breaking operation is preparing the meat for the washing and comminuting operations. A breaking machine ordinarily consists of a series of knives which cut the meat into smaller pieces. This is similar in construction and operation to the cutting machines used in the cane sugar manufacture.

Washing.

The washing operation consists in passing the broken pieces of meat under a spray of water to take away the dust and other impurities from the meat surface. The washing machine may consist of perforated vibrating jigs through which the wash water can pass. Vibrating jigs are most commonly used in the mining and quarrying industries.

Comminuting.

This operation prepares the washed meat for the pressing operation. Ordinary grinders for meat, rocks and other fibrous materials, or even the shredding machines used in desiccated coco-nut plants may be used here. The current practice, however, favours the disk grinders which break the meat into small sizes by the shearing action caused by the rotating disks. Disk grinders are most commonly used in the desiccated coco-nut plants.

Pressing.

This operation is done by feeding the ground meat into a series of roller presses (like flaking rolls) to express the juice or the "gata" from the meat. It has been found that in order to get the maximum possible percentage of oil extraction by the use of roller presses, the following factors must be considered:—

(1) Method of feeding the ground meat into the rollers.
(2) Water of dilution.
(3) Pressure between the rollers.
(4) Successive order of pressing.
(5) Speed of the rollers.
(6) Particle size.

From the standpoint of mechanization, factors (1), (3) and (5) should be carefully considered. All these factors have been studied in pilot plant operation, and it has been found that all of these factors can be controlled to get a total oil extraction of as high as 98 per cent., and an average extraction of around 77 per cent. in the first pressing, 85 per cent. in the second, and 94 per cent. in the third and last pressing. These figures clearly show that the roller press is an efficient machine for extracting the "gata". The method of feeding can be so mechanized as to give the minimum time of pressing for a given percentage of oil extraction. If it is required to get the most oil from the meat, then a duo-expeller, like the one used in the copra mills, could be incorporated after the first set of roller presses. The dried sapal could be fed to the expeller to have most of the oil expressed and a cake low in oil content but fairly high in protein content could thus be obtained. With the proper combination of the factors mentioned above and the proper mechanization for feeding, it can be experimentally shown that a very simple machine such as the roller-press can be used to get a high percentage of oil extraction from the coco-nut meat.

Separation of the Oil.

This operation consists first in passing the "gata" through a suitable centrifuge having low speed to separate the cream, consisting primarily of oil and protein, from the maceration water, containing most of the sugar and a part of the protein. Suitable equipment for this operation would be a solid-ejecting centrifuge, where, by means of pressure, the solid accumulating inside would be ejected, rendering a continuous passage of the "gata". Pilot plant experiments show that a Westphalia non-ejecting centrifuge with a small bowl capacity could be used, but in commercial practice a solid-ejecting centrifuge would prove very efficient. It should be pointed out that these centrifuges are used in various industries, among which are the manufacture of yeast, the recovery of lubricating oils, &c.

After the treatment of the diluted cream in the cream-treatment tanks, it is then passed through a solid-ejecting centrifuge where the protein solids and the waste water are separated from the oil. The centrifuge used here is the same in construction as the one used in the centrifuging of the "gata", but runs at greater speed to ensure the complete separation of the oil.

In connexion with the centrifuging operation small centrifuges which need not be solid-ejecting may be used to recentrifuge the "skimmed milk" and the waste water to recover most of the cream and the oil, respectively.

Materials, Handling and Storage.

For the continuous flow of meat from washer to comminuter, and of the coco-nut shells from the shelling section to the power-house, ordinary chain belt-conveyors may be used. Liquid centrifugal pumps can be used for transporting the "gata" from the troughs below the roller presses to the wood tanks before it goes over to the first centrifuge. The cream could be transported from the centrifuge to the cream treatment tanks by means of displacement pumps.

For purposes of storing the "gata" and the treated cream, wooden tanks are preferable, as found by experiments. Oil is usually stored in tin-lined cans or in large oil tanks of riveted steel plates. In case of blockade and shortage of tin cans or any other metallic containers, other native materials may be used. There are now investigations being made to determine the keeping qualities of oil in gasoline cans, galvanized sheet cans, wooden tanks, and other native materials.

Processing of By-products.

The coco-nut sapal or cake coming out of the roller press goes to a drier. The drying operation may be made intermittent with the use of tray driers, or it may be made continuous with the use of a revolving conveyor drier. Both kinds of driers are being used in desiccated coco-nut plants. The dried sapal is then ground in a pulverizer, preferably a hammer mill, to reduce it to flour particle size. The coco-nut flour may be packed in cloth bags or any other package depending on the demand, and sold as flour substitute. The analysis of this flour is discussed fully in another paper, and it is sufficient to say that good bread and cakes can be made from it by incorporating with wheat flour, cassava, &c.

The "skimmed milk" or maceration water is probably potentially the most important by-product of the process, for the following reasons:—

(1) Its protein constituent contains all the amino acids necessary for normal growth, as found by several American investigators.

(2) It contains plenty of carbohydrates mostly in the form of sugars, and a fat content which can be varied at will.

(3) Its nature and composition permit its processing into different products which can replace imported milk and milk products.

How the coco-nut "skimmed milk" is to be processed depends on the nature of the product to be manufactured. As an example, the "skimmed milk" may be spray dried just like powdered milk. This processing entails the use of a vacuum evaporator on the same principle of the vacuum pan used in cane-sugar manufacture. The concentrated milk is then dried in a spray drier by means of hot air. The problem of spray drying has been thoroughly studied in the milk industry, so that there will be no difficulty of its application to the coco-nut "skimmed milk", a product very similar to milk.

The manufacture of coco-nut syrup again requires evaporation of the "skimmed milk" and compounding with sugar and other ingredients to suit the taste. Again this process is only an adaptation of the process of making syrup or coco-honey from the coco-nut "gata". There are numerous products that can be formed from the coco-nut "skimmed milk" which can compare with the products of natural artificial milk. However, the two above-mentioned offer the greatest possibilities, so for the present they are the only ones discussed.

The protein solids deposited from the centrifuging of the "gata" and the treated cream have been found to contain a very high percentage of protein. These solids can be incorporated with the coco-nut flour to increase its nutritive property, or they may be mixed with squash, &c., for making candies, or they may be separately processed to give amino acids in their pure form for feeding experiments and for food compounds. The production of amino acids from these protein solids requires the use of resistant cookers, reaction kettles and evaporators, and a great amount of technical control. However, this need not go with an oil plant and can, therefore, be processed in a small separate processing plant.

Summary.

From the above discussion it is clear that all the machines used in the manufacture of coco-nut oil and by-products by the Lava process are being used in allied industries and, in some cases, in totally different industries. For this reason the machinery and equipment cannot be classified as belonging to special types. Hence, under favorable conditions, it would not be difficult to procure at regular prices some of that equipment which cannot be fabricated locally.

From the standpoint of the choice of machinery and equipment, therefore, the manufacture of coco-nut oil directly from fresh coco-nut meat by the Lava process is commercially feasible.

ENTOMOLOGICAL NOTES.

By John L. Froggatt, B.Sc.

Department of Agriculture, Rabaul.

Fruit-piercing Moths.

These pests are generally distributed throughout the Territory, and may cause loss of large quantities of fruit, especially citrus—citrus, bananas, tomatoes and pawpaws being among the fruit recorded as being attacked by these moths.

The adult of *Othreis fullonica* L. is a large moth with the forewings dark brown on the upper surface, and the hindwings yellowish-red with black markings—the abdomen is the same general colour as the hindwings. The mouth-parts are prolonged into a tube with a sharp point, by means of which they puncture the skin of the fruit and suck up the juice. Rot and fermentation set in around the puncture and the fruit falls to the ground and becomes inedible.

The caterpillars vary in colour from jet black to rich brown with white tracery markings on the body. Characteristic markings on the sides of the grubs are two round whitish marks resembling "eyes" on each side of the fore portion of the body.

The moths fly at dusk, and can easily be seen on ripening fruit, when they can then be killed by "swatting".

Recently, at the Agricultural Demonstration Plantation, Keravat, situated on the Keravat River, about 30 miles from Rabaul, the grubs of this moth occurred in plague proportions on *Erythrina lithosperma*, and spread into *Erythrina variegata* and *Erythrina* (*Micropterux*) *poeppigiana*, stripping the trees bare of foliage. This was a serious matter, as these trees were used as permanent shade for cocoa, and, as a result of the loss of shade foliage, the cocoa trees were fully exposed to the sun. The laval period was not determined, but the pre-pupal and pupal period combined was fourteen days. Pupation occurred on the tree, two or more leaves being webbed together.

Erythrina spp. have previously been observed to be attacked by this pest in other parts of the Territory, often resulting in very serious defoliation. The indigenous species is evidently the natural host of these moths.

Another species of fruit-sucking moth also occurs in the Territory, *Othreis salamina*. In this species, the forewings have a greyish-white margin with the remainder velvety-green in colour. The habits are similar to the former species.

In view of the heavy defoliation of *Erythrina* spp. by these pests, its continued use as shade trees for cocoa and other crops will have to be carefully reviewed, owing to the risk of damage to the crop foliage due to exposure to the full sunlight.

Tobacco Pests.

The following insect pests have been bred from tobacco plants:—

- *Lepidoptera*—
  - *Noctuidae*—
    - *Prodenia litura* F., on foliage.
    - *Cirphis unipuncta* Ham., damaging seedlings at ground level.
    - *Plusia signata* F., on foliage.
  - *Pyralidae Psara hipponalis* Wlk., stem borer.
  - *Gelechiidae Phthorimaea heliopa* L., stem borer.

The leaf-eating caterpillars, if present in numbers sufficient to cause economic damage, can be controlled by using derris dusts.

The stem-boring grubs usually occur in the seed-beds, or soon after the young plants have been set out in the field. Hilling the soil around the base of the plants will assist the development of new roots above the portion damaged by the pest.

Cutworm larvae, such as those of *Cirphis unipuncta,* usually shelter just under the surface of the soil during the day, coming out at dusk to feed. Wherever a plant is found damaged close to the ground, if the soil is turned over, the grubs will usually be found, and can then be destroyed before any further damage can be effected to other plants. Where this pest occurs in appreciable numbers, scattering of Paris green-bran bait is the most effective measure for combating it. This is made up in the following proportions:—

Bran or pollard	25 lb.
Paris green	1 lb.
Molasses	1 quart

Juice of 6 lemons or "moolies".
Water sufficient to make the mass damp but crumbly.

The bran and Paris green are thoroughly mixed, dry, and the water, in which the molasses and fruit juice have already been mixed, added slowly with thorough stirring. It is usually advisable to make up the amount required in the morning, and scatter along the rows of plants in the late afternoon.

Fruit Flies.

Another common source of loss of fruit is caused by the maggots of fruit flies infesting the pulp, causing it to rot and ferment. The flies lay the eggs just under the skin of the fruit, and the maggots penetrate all through the tissue.

The following species of *Trypetidae* have been collected or bred from infested fruit, or, in one case, from mines in foliage of a species of *Aralia*:—

Species.	Locality.	Host.
Dacus pectoralis Walk.	Manus	Collected
Dacus curvifer Walk.	Rabaul	Collected
Dacus frenchi Frogg.	Rabaul	*Artocarpus communis*
Dacus speculifer Walk.	Rabaul	Collected
Dacus ferrugineus var. *incisus*, Walk.	Huon Gulf	Collected on banana fruit
Dacus frauenfeldi Schin.	Rabaul	Mango, *Eugenia jambosa*
Dacus peculiaris Mall.	Rabaul	*Artocarpus communis*
Dacus obliquus Mall.	Rabaul	*Artocarpus communis*
Enoplopteron hieroglyphicum de Meij.	Huon Gulf	Collected
Hemilea araliae Mall.	Rabaul	Leaf miner in *Aralia* sp.
Nesthemara exul Curr.	New Ireland	Collected
Rioxa flava Edw.	Manus	Collected

The degree of infestation by these pests varies considerably in different years, even in two successive years.

Banana Pests.

The banana is an important item of diet with the natives, especially in the Gazelle Peninsula of New Britain, otherwise, apart from the local supply of a relatively small quantity of the ripe fruit for European consumption, there is no commercial aspect to be considered with this crop.

The following pests have been recorded in this Territory in connexion with this crop:—

Coleoptera—

Dynastidae Papuana laevipennis Arr. and *Papuana* spp.

Curculionidae Cosmopilites sordida Chev.

Lepidoptera Pyralidae Lamprosema octasema Meyr.

The *Dynastida* are small brownish-black beetles about ¾ inch in length. In dry weather, especially, they may bring about the destruction of many small suckers, when freshly planted out, by feeding into the growing point. They are much more serious than the banana weevil borer, *Cosmopilites sordida*, which is comparatively rare at low levels.

The fruit moth, *Lamprosema octasema*, lays its eggs on the young fruit just after the flower bracts lift, and the caterpillars feed on the surface tissue, leaving scabby patches, which, except in extreme cases, affect the appearance of the fruit, but do not affect its palatability.

An unidentified species of thrips is common in the flowers, but does not appear to do any damage.

" Nezara viridula smaragdula " F.

This *Pentatomid* bug breeds freely on cowpeas and rice, as well as other crops, and may be one of the pests causing " whitehead " of rice due to feeding on the ear when the grain is forming. The eggs are creamy-yellow in colour and are laid, usually, in a symetrically arranged mass in rows on the under-surface of the leaf; the number in any one mass shows considerable variation, but has totalled as many as 119.

The head capsule begins to show through the chorion in two and one-half to three days after oviposition, when the eggs are faintly pink in colour. The egg stage occupies four to six days, and the first instar nymphs remain as a cluster around the egg mass for about 48 hours before beginning to disperse.

The nymphal stages occupy 27 to 28 days, making a life-cycle of 31 to 34 days.

COCO-NUT RECIPES.

Coco-nut Butter.

Coco-nut butter is being very largely used in place of dairy butter in the United Kingdom and France, and, before the war, it was largely used in Germany. It can be used wherever dairy butter is used. Here is the process:—Grate or grind in a mill the meat of the nut as fine as it can be ground, and for the meat of each average nut add a pint of boiling water. Put this in a press, so that the milk can be squeezed out separate from the pulp. This milk can be used in place of cow's milk for any purpose, and is specially good with stewed fruit. To make butter, this milk can be separated in a separator or let stand in a pan to let the cream rise, which it should do in about the same time as the cream in cow's milk. This can be set to ripen and churned in the usual way. The whole process is in every respect the same as in making dairy butter. Wash out the buttermilk; add salt to taste. As a rule, this butter is white, and annatto colouring can be added. According to the size of the nuts, it should take from six to ten nuts to make 1 lb. of butter. The churning should be done in a cool temperature, say, between 60 to 70 degrees.

Coco-nut Cream.

This may be used with a variety of dishes in the same way as dairy cream; added to gelatine, bread, corn starch, or rice puddings, it imparts a delicious flavour without the objectionable feature of grated "meat": there is nothing better to serve with fruit, either fresh or preserved, than a few spoonfuls of this cream poured over the dish just before serving.

To prepare this cream, grate the "dry", or ripe, coco-nut and to the grated meal add enough boiling water to cover; stir with a tablespoon for one minute and then squeeze through a strainer cloth. The semi-fluid cream has not only the true coco-nut flavour, but it is both a rich and easily digested food and a delightful flavouring extract. Another method produces a slightly different article: to one grated coco-nut add ¾ litre of boiling water; let this stand until cold, then skim off the cream which will have risen to the surface.

Ambrosia.

Add grated coco-nut pulp to shredded orange, pineapple and sliced bananas. Mix thoroughly and sweeten with confectioner's sugar; this delicious dish may be decorated with maraschine cherries.

Coco-nut Ice Cream.

To the cream from six small or four large ripe nuts, add an equal quantity of "natural" tinned milk; sweeten to taste, and add vanilla or other flavouring.

Coco-nut Ice.

Mince the jelly of six unripe coco-nuts and add 1 litre of the water therefrom; sweeten to taste; no flavouring is required as nothing can improve the taste of this sherbet.

Coco-nut Rice.

To the grated meat of one coco-nut add two cups of hot water; squeeze this in a strainer cloth and add sufficient water to make four cups of liquid; add four tablespoons of sugar, a spoonful of ginger, and two cups of rice; cook in a double boiler for nearly one hour. Serve for dessert. (In Spanish America, ginger is almost always added to coco-nut dishes; it promotes digestion.)

Coco-nut Savoury.

This is the justly famous Spanish dessert dish of the West Indies. To the grated meat of one large, ripe coco-nut, add one cup of hot water and squeeze through the strainer until all the "milk" is extracted; to this creamy liquor add the beaten yolks of four eggs and four tablespoons of white sugar. Heat slowly, stirring well until a thin custard-like coating forms upon the spoon. Remove from the stove and when nearly cold pour over small slices of sponge cake. Finally, spread over the dish a layer of egg whites thoroughly beaten and sweetened. Serve as cold as possible.

Love Powder.

This is also one of the commonest dessert dishes in Spanish America and is worthy of much greater popularity; it often accompanies the preceding. To the grated meat left after the extraction of the cream for the previous dish, add several tablespoonfuls of moist brown sugar and toast slowly in a deep iron skillet, stirring constantly until the coco-nut assumes a light-brown colour. Serve hot. This dish keeps well for several days, but it should be placed in the oven a few moments each time just before serving.

Coco-nut and Tapioca Pudding.

Mix one cup of "minute tapioca" with four tablespoons of grated coco-nut "meat", the yolks of four eggs well beaten, one cup of white sugar and 1 litre of "natural" tinned or dairy milk. Bake for one-half hour and add meringue made of the whites of four eggs and three tablespoons of sugar.

Coco-nut Soup.

To common clear beef-stock thickened with barley or corn starch, add the "cream" of one coco-nut and one teaspoon of curry powder (previously moistened with cold water); this must not boil after the coco-nut is added.

Coco-nut Candy.

Cook one-half kilo, of brown sugar with one-half cup of hot water until it hardens when dropped into cold water. Add the grated "meat" of one coco-nut and one-half teaspoon of ground ginger, one-fourth teaspoon of ground cinnamon, and one teaspoon of vanilla extract. Cook again until the mixture will harden in cold water; pour into buttered tin to cool. Cut into squares.

Filling for Coco-nut Pie.

To the grated "meat" of one ripe coco-nut add one-fourth kilo. of white sugar well beaten with four eggs; flavour with vanilla or with lime or lemon juice.

(1 litre = 1 quart, approximately; 1 kilo. = 2¼ lb., approximately.)

NOTES ON GREEN MANURING.

By E. C. Green, A.I.C.T.A.(Trin.), H.D.A.

Demonstration Plantation, Kerarat.

Green manuring means the digging into the soil of growing crops so that the roots, stems and leaves can rot in the soil and so improve it. Sometimes the whole crop may be dug into the soil, such as cowpea when it flowers, or a crop may be pruned and the prunings dug into the soil such as the prunings from *Crotalaria* or *Tephrosia* when used as a temporary shade.

As a rule, legume crops are generally used for green manuring because they have the power of absorbing nitrogen and releasing it in the soil whilst the crop is growing. Nitrogen is very important for plant growth, and, without nitrogen, it is impossible for crops to grow and produce, and, the fact that a legume absorbs atmospheric nitrogen, makes it very valuable for green manuring.

Another plant food is humus which consists of decayed and decaying plant or vegetable material. For example, if we bury a leaf in the ground it very quickly rots or decays and becomes very small pieces of leaf which cannot be seen with the eye—the leaf is now said to have turned to humus. Thus, it will be seen that green manuring helps to keep up the humus supply in the soil, and, in addition, the plant food stored in the roots, stems, branches, leaves and flowers of the green-manure crop are returned to the soil, and food, such as nitrogen, is increased in the soil.

In the tropics, green-manure crops can be divided into two groups, namely:—

(1) Annual, and
(2) Non-annual.

Annual Green-manure Crops.—Cowpea, mungo bean, peanut, lima bean, velvet bean, annual *Crotalaria,* winged bean.

Non-annual Green-manure crops.—*Crotalaria, Tephrosia, Indigofera arrecta, Leucaena, Erythrina, Mimosa, Pueraria, Centrosema, Desmodium, Calopogonium.* The first five crops are erect and the last five are creepers.

Cultivation of Green Manure Crops.

Annual.

The cultivation of all the above annual green-manure crops, with the exception of annual *Crotalaria,* has already been given (*vide New Guinea Agricultural Gazette,* Vol. 7, No. 3). It is important to note that a green-manure crop must be dug into the soil when it is in full flower if the maximum benefit is to be obtained.

The chief annual *Crotalaria* variety used is "Sunn Hemp", a quick-growing *Crotalaria* which can be dug into the soil as green manure or harvested for making fibre. The crop grows about 6 feet high, has yellow flowers, grows best during the drier part of the year, will not stand constant wet weather and the seeds are larger than the usual *Crotalaria* seeds and are dark coloured. For green manure, the seed is sown broadcast or in rows 1 ft. 6 in. to 2 feet apart, the seed being spaced 1 foot apart in the rows.

NON-ANNUAL.

The "Giant" *Crotalaria* is the variety of *Crotalaria* most commonly used. It is a quick-growing shrub, 6 to 8 feet high, which lasts for about two to two and a half years. It gives a great deal of green material and can be pruned back three to four times a year.

Wet soils are totally unsuitable for *Crotalaria*; the soil must be well drained. The climate should be hot and moist, although *Crotalaria* grows very well in dry areas.

As a green manure to improve cultivated land, the seed may be broadcasted or planted in rows 4 feet apart, and the seed spaced 2 to 3 feet apart in the rows. When used as a combined temporary shade and green manure in young *cacao* or coffee it is planted between the rows of *cacao* or coffee.

The "Giant" *Crotalaria* is easily distinguished by the height to which it grows, the yellow flower, the fairly large yellowish-coloured seed which rattles in the pod, and the short, thick pod.

For green manure, the crop is pruned back to a height of about 4 feet, three or four times a year, and the prunings are either buried in trenches, dug into the soil, or allowed to remain on the surface of the land to rot. *Crotalaria* is a very good green manure and makes a lot of nitrogen available for the soil.

Tephrosia candida.—This is a legume, grows 6 to 8 feet high, is quick growing, has fairly long narrow leaves, white flowers, and long narrow pods containing a number of flat mottled-coloured seeds. It is used as a temporary shade for permanent crops, such as *cacao*, to control grass and weed growth in coco-nuts and rubber, and as a green manure.

As a green manure, *Tephrosia* is usually planted in rows 4 feet apart and the seed spaced 3 feet apart in the rows. As temporary shade, it is planted either in the same row as the *cacao* or between the rows. For green-manure purposes, *Tephrosia* is pruned back three to four times a year in the same manner as *Crotalaria*, and the prunings are buried, dug into the soil, or allowed to remain on the surface of the land to rot.

Tephrosia needs the same soil and climate as *Crotalaria*, but is deeper rooting, does not blow over so easily, produces a great deal of green material, and will last for about three years.

Indigofera arrecta.—This is a legume which grows to a height of 8 to 10 feet, the flowers are small, the seed pods small and clustered along the stems and branches, the seeds are very small and square in shape, and the leaves are short and fairly broad. *Indigofera* is not used so much as *Crotalaria* and *Tephrosia*, although it yields a large amount of green material and lasts about three years.

When planted as green manure, the seed can be sown broadcast or in rows 4 feet apart. The crop is pruned in the same manner and the prunings treated in the same way as *Crotalaria* and *Tephrosia* prunings.

Leucaena glauca.—This is a legume which grows to a height of 25 to 30 feet, the leaves are long and narrow, the flowers look like a small white ball, and the pods are long, flat, about ¾ inch wide and contain many shiny, flat, dark-brown seeds. *Leucaena*, in addition to being one of the most valuable green-manure crops in cultivation, is also used as a permanent-shade tree in the cultivation of coffee and *cacao*.

For green-manure purposes, the seed is planted in rows 4 feet apart and 3 feet apart in the rows, and when the plants are about 5 to 6 feet high, they are cut back to about 1 foot high and allowed to grow up again. *Leucaena glauca* can be cut back continuously and is a permanent tree. The prunings are treated in the same manner as the other green-manure crops.

Erythrina lithosperma.—This is a legume which grows to a height of 25 to 50 feet, the leaves are large and somewhat heart-shaped, the flowers are red, the seed is fairly large, most varieties have thorns on the stem, and the leaves, branches and stems are a light-green colour.

Erythrina is generally grown from cuttings, i.e., pieces of branches, about 3 ft. 6 in. to 4 feet long, are placed in the ground about 2 feet deep and at an angle. One variety of *Erythrina* is used a great deal in some countries as shade for coffee and *cacao.*

Erythrina is not a strong-rooting tree and hence is liable to be blown over by wind. The large leaves provide a great deal of green manures, but the tree is not very popular because it is very subject to attack by caterpillars and other insects.

Mimosa invisa.—This is a creeper which is easily recognized by thorns on the stems and branches and leaves which close up when touched.

Mimosa is also known as " sensitive plant ", but the variety which is of such importance as a green manure is different from the one which grows in the Solomon Islands.

Mimosa flowers look like small light-purple coloured balls, the seed is small, flat, light-brown in colour and has a point at one end. In planting, either seed, seedlings or cuttings can be used, seed being best and most reliable. When planting small hills are made about 15 to 20 feet apart and a few seeds planted in the top of each hill. It is advisable to soak *Mimosa* seed in water for twelve hours before planting.

The *Mimosa* spreads over the ground, eventually covering it, killing grass and weeds. Being a legume, the roots are covered with nodules, hence, *Mimosa* makes available a lot of nitrogen and is, therefore, one of the best creeping green-manure crops that can be grown. It can be grown and allowed to remain on the land for many years, although after one or two years, if the land is needed for cultivation, the *Mimosa* can be dug into the soil.

Pueraria javanica.—This is a creeping legume which is easily recognized by its large leaves, and thick stems covered with very fine hairs. The flowers are small, light-purple to white in colour and boat-shaped; the seed-pod is long, narrow, round, black or dark-brown in colour and the seed is small, hard and dark coloured.

Pueraria can be used as a green-manure crop or as a cover crop in coco-nut plantations. It is grown from seed or cuttings, but if the latter are used, care must be taken that they are planted lengthways and not more than 1 inch deep, and that dull, cloudy, wet weather prevails during and after planting. *Pueraria* grows quickly and one plant can spread more than 30 feet in one year, thus is *Pueraria* a valuable crop for covering the ground and killing grass and weed growth. It will grow in almost any type of soil, and at Keravat does well on wet soil and on nicely drained soil. *Pueraria* will also withstand a fairly long period of dry weather.

The large leaves and stems provide a great deal of green material which makes valuable humus for the soil, and if grown on land that has been cropped many times or for a number of years, the top is cut off twice a year and the crop allowed to re-establish again. By cutting back, more green material is made available for humus.

Pueraria and *Mimosa* are the two best non-annual, creeping green-manure crops and soil improvers that can be grown.

Centrosema pubescens.—This is a creeping legume with small, dark-green leaves, thin wire-like stems, large boat-shaped purplish flowers, and long, slender, narrow, flat seed-pods containing fairly large, roundish seeds, which are a dark, streaky colour.

Centrosema can be grown from seed or cuttings, and if cuttings are used then the same care must be taken when planting as with *Pueraria*. *Centrosema* is also used as a cover crop in coco-nuts. It will not grow on such a variety of soils as *Pueraria,* and needs a soil that is well drained and fairly fertile. It will, however, withstand long dry periods.

Desmodium scorpiurus.—This is a creeping legume which is a native of New Guinea. The leaves are roundish and light-green in colour, the stems are soft and fairly hairy, the flowers very small, and seed is rarely produced. *Desmodium* is generally grown from cuttings, and it grows quickly and easily. It is not as good as *Mimosa* or *Pueraria* as a green manure or for the control of grass and weeds, but is excellent ground cover for crops such as *cacao* and coffee which require a low, ground-cover crop.

Calopogonium mucunoides.—This is a creeping legume, which, on first appearance, looks like *Pueraria*, but the leaves are only half as large, the stems are much smaller, the flowers are very small, the seed-pod is short, flat and covered with tiny hairs, and the seed is square-shaped and yellow in colour.

Calopogonium seeds freely and is grown from seeds or cuttings. It grows quickly, but will not stand dry weather and every year or eighteen months dies off.

Often *Calopogonium* is planted with *Pueraria* or *Centrosema*, the *Calopogonium* growing quicker than these two crops, forms a quick cover. By the time the *Calopogonium* has died back the *Pueraria* or *Centrosema* has become established and provides the ground cover and green manure.

METHOD AND TIME OF APPLICATION OF FERTILIZERS.

The value of fertilizers for promoting vigorous and abundant crops is largely determined by the time and method of their application. Applied at the right time and in the proper manner, fertilizers stimulate the growth of the crop from the start and result in heavy yields. On the other hand, premature, late or faulty distribution all militate against good results, because, thereby, the fertilizer is prevented from exerting its full influence and consequently its effects are uncertain.

There are various methods of applying fertilizers to the soil, some of which have certain advantages over others, depending on the nature of the crop and the conditions obtaining on the plantation. In applying fertilizers, two things must always be kept in mind, firstly, the necessity for even distribution, and secondly, the necessity for thoroughly incorporating the fertilizer with the soil. The fulfilling of these two conditions is essential to the success of the manuring.

The reason is obvious, for, where the fertilizer is unevenly distributed, some areas receive abundant plant food, while others receive little, or, possibly, none. The plants, therefore, in the former areas receive more than enough for their requirements, while those in the latter soon fail from deficiency of available plant food. The result is that the yield is decreased more or less considerably. With even distribution, however, each plant is provided with a sufficiency of food and a uniformly vigorous growth and good yield are obtained and no manure is wasted.

The thorough working-in of the fertilizer is equally important, as it ensures the fixing and rendering available of the contained plant food by the soil and the placing of it at a depth where the roots of the crop plants will easily reach it. Moreover, the working-in of the fertilizer improves the physical condition and the water-holding capacity of the soil and also helps to prepare a good seed-bed for the coming crop. A good seed-bed is, of course, necessary, as the fine texture of the soil promotes the development of capillary roots, which enable the plant to avail itself quickly and more fully of the plant food in the soil.

One method of distributing fertilizers and a method which may be adopted under most conditions, is the broadcasting of the fertilizer over the surface of the soil and subsequently working it under with the hoe, harrow or plough. In districts where labour is cheap, broadcasting may be done by hand, an even distribution being easily effected by skilled coolies. The use of fertilizer distributing machines, where available, may possibly be a cheaper method, especially as the employment of skilled labour is not necessary. In broadcasting, in order to ensure even distribution, it is usual to traverse the field first lengthways and then across.

If the fertilizer is applied in the drills, we may obviate any loss such as might occur in broadcasting, but this method has its disadvantages, as presence of a high concentration of plant food might have a toxic action on the seed and impede its germination. This is a risk which is hardly compensated by saving the very small amount of fertilizer which might be wasted during broadcasting.

In fertilizing permanent crops, such as tea and fruit crops, it has been the custom in some places to restrict the application of the fertilizer to a comparatively small area round the plant, usually that area shaded by the branches. In the case of young trees, the lateral roots of which are not sufficiently developed, the application of the manure to a restricted area round the stem is advisable, since the area over which the plants feed is small. In later stages of development, however, the root system of these plants occupies a considerably larger area than that covered by its branches, and therefore the restriction of manuring to this area results in the nourishing of only about one-half of the roots, the outermost having to depend on the store of plant food provided by nature. As this is usually insufficient to maintain vigorous growth, the efficiency of this part of the root system is impaired and the area on which the plant draws for its food is gradually diminished.

A better method of manuring these crops is to extend the area round the plant every time fertilizers are applied, in order to encourage the development of a wide-flung root system. This will enable the plant to avail itself more fully of the plant food and moisture in the soil and also to resist better the effects of drought.

As already stated, the application of fertilizers at the right time is most essential. The time of application depends on the nature of the fertilizer and of the crop. For most crops there are certain general rules as to the time of applying fertilizers.

Potash manures should be broadcast and worked into the soil some time before planting, in order that the potash may be dissolved in the soil and be available when required by the crop-plant.

Phosphates, especially the less soluble forms, should be applied some months before sowing or planting, in order that they may be rendered soluble and readily assimilable by the time they will be required by the plant. On light soils superphosphate may be applied just before planting.

Nitrogenous fertilizers, especially nitrates, may be applied during growth as a top-dressing, the application taking place just before rain is expected or where irrigation is employed, immediately before watering. In using sulphate of ammonia or nitrate of soda as a top-dressing, care must be taken not to apply them when the plants are wet, as the fertilizers falling on the wet leaves are apt to burn them.

When the less soluble nitrogenous manures are employed, application must take place earlier, the manure being worked in some months before planting. This enables nitrification to take place, so that the contained nitrogen will be in a readily available form when required by the plant.

In the case of perennial crops, manuring should take place during the resting period, for instance, at or towards the end of the rainy season. The fertilizers are then washed in to the soil, where they are rendered available for the crop when its new period of growth commences. With crops such as oranges, &c., which bloom in spring, it must be remembered that the flowers are produced on wood matured in the preceding season, and thus the bloom and young fruit are dependent for their development on food assimilated during the previous season, and the manuring programme should be arranged accordingly.

With crops such as oranges, tea, &c., better results will be obtained if fertilizers be applied over a long period, rather than all at once. To young plants the fertilizer should be given in two instalments, whereas with older crops, application in four dressings may give better results.—(*Jacob and Coyle.*)

NEW DEVELOPMENT OF POTASH PRODUCTION.

To replace essential supplies of potash formerly obtained from Germany and Palestine, the Western Australian Government, in co-operation with the Commonwealth Department of Supply and Development, the Commonwealth Council for Scientific and Industrial Research, and commercial interests are making preparations with a view to producing potash from alunite deposits in the bed of Lake Campion, Western Australia, 250 miles from Perth. Many agricultural industries, especially sugar-growing, depend on a continuous supply of potash for fertilizers.

It is estimated that 2,000,000 tons of alunite are available at Lake Campion in deposits which could be removed readily by dredging. From this quantity it is estimated that 250,000 tons of potassium sulphate could be produced, sufficient to meet Australian requirements for 25 years at the present rate of consumption.

It is proposed to produce 200 tons a week, which would meet the Commonwealth demand. Australia normally imports about 12,000 tons of potash salts annually, and it is estimated that two-thirds of the total are used for agricultural fertilizers in the form of potassium sulphate and potassium chloride. Potassium sulphate is the basis of the potassium chlorate used in making matches and explosives, and in pharmacy. So far, no plant for the manufacture of chlorate exists in Australia.

Before the war Australia obtained potassium chlorate principally from Germany, Sweden and Switzerland. Australian firms handling potash, fearing a shortage such as occurred in the last war, have built up stocks which are expected to last for twelve months. By the end of that period it is hoped that the Western Australian plant will be producing commercially.

The production of other forms of potash from wool is being investigated. The sweat in wool is composed largely of potassium soaps, which can be obtained by steeping the wool before scouring.

It is estimated that sufficient potassium carbonate and potassium hydroxide for Commonwealth requirements can be produced from this source. In these forms potash is used in the making of soft soaps and in the preservation of dried fruits, where it is of great importance. In the year ended 30th June, 1939, Australia imported from Germany 10,709 cwt. of potassium carbonate and pearl ash and 7,991 cwt. of potassium hydroxide. (From *Chemistry and Industry*, 60, 4, 52.)

SOAP-MAKING.

With the object of cutting down expenses and using up some of the copra which they are unable to sell, many planters are now making soap, both for their own and native use. Many planters have satisfactory recipes, but the majority are always anxious to try others, particularly if they are cheap. Already two recipes have been published in this *Gazette*, and a third, kindly supplied by the Catholic Mission of the Holy Ghost at Alexishafen, will now be presented. Any planters, having other recipes which they have found to possess special merits, are invited to submit them to the Editor for publication.

1. 100 lb. of coco-nut oil or two-thirds coco-nut oil and one-third rendered animal fat.
2. Ash solution.—This consists of the ground ashes of coco-nut husks mixed with water until a consistency of 8 degrees is registered on a Baumé Aerometer.
3. Soda solution.—To 16 gallons of cold rain water add 100 lb. caustic soda.

Method:

The oil, or oil and fat, is heated to a temperature at which one may just hold a finger in without being burned. Ash and soda solutions are then added and stirred in well. The mixture is then allowed to boil for one-half to three-quarters of an hour. This process of adding ash and soda solutions and boiling is repeated until the soap has acquired the desired consistency. The test is made by placing a small amount of soap on a plate and allowing it to cool. The soap should be stiff enough after about the sixth or seventh boiling.

For the first addition, 47 lb. of ash solution and 3 lb. of soda solution are added when the mixture should register 13° Baumé. The other additions are as follows:—

1st	addition,	50	lb. ash and soda	=	13° Baumé.
2nd	,,	30	,, ,, ,, ,,	=	15° ,,
3rd	,,	25	,, ,, ,, ,,	=	18° ,,
4th	,,	20	,, ,, ,, ,,	=	20° ,,
5th	,,	20	,, ,, ,, ,,	=	22° ,,
6th	,,	20	,, ,, ,, ,,	=	25° ,,
7th	,,	22	,, ,, ,, ,,	=	27° ,,
8th	,,	30	,, ,, ,, ,,	=	25° ,,

After the desired consistency has been obtained, the soap is allowed to stand twelve to fourteen hours, then 1 quart of cold coco-nut oil is well mixed in to give the soap a glossy, finished appearance. On the addition of the cold oil, the soap should not be too cool or it will go streaky. The soap is then poured into convenient forms until it is hard enough to cut.

Usually, some liquid remains under the soap, which can be used in the next soap-making. It replaces about one-third the required amount of soda. Dyes and antiseptics may be added to the soap.

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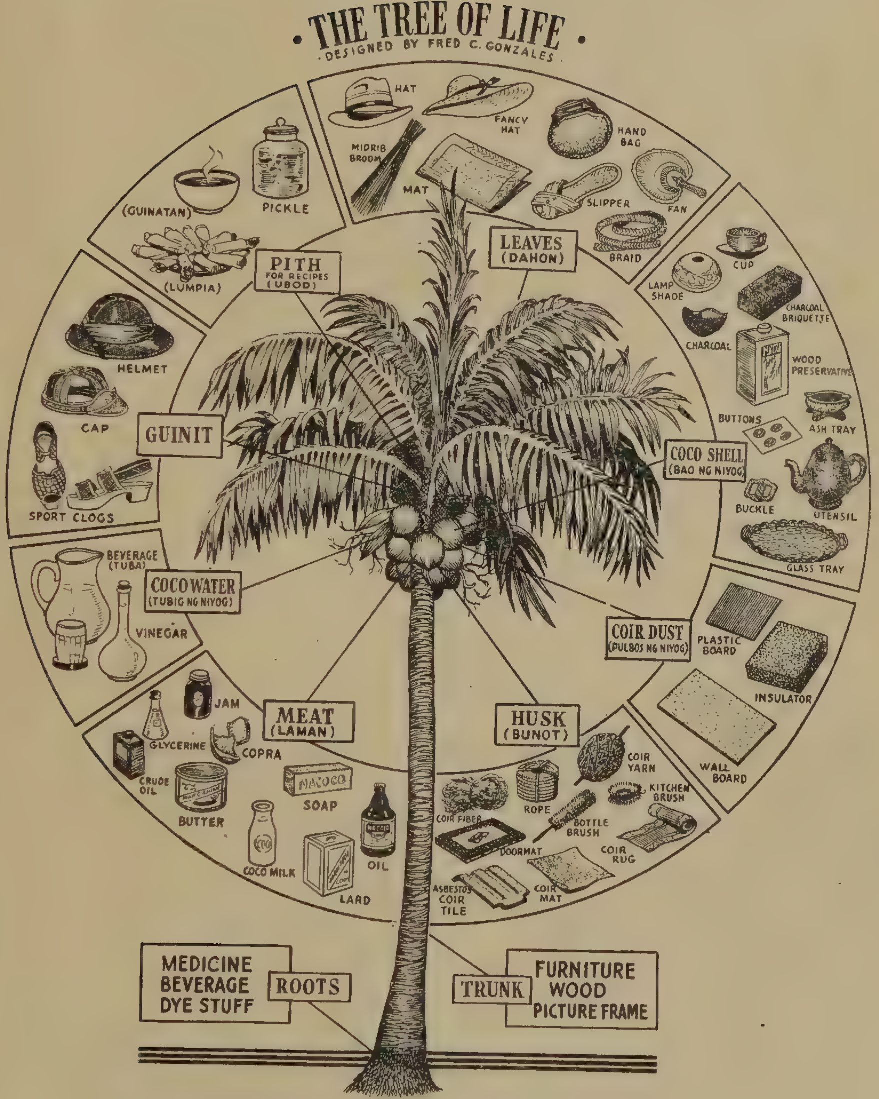
THE TREE OF LIFE
DESIGNED BY FRED C. GONZALES
HAT
FANCY HAT
HAND BAG
MIDRIB BROOM
MAT
SLIPPER
FAN
BRAID
LEAVES (DAHON)
PICKLE
(GUINATAN)
(LUMPIA)
PITH FOR RECIPES (UBOD)
CUP
LAMP SHADE
CHARCOAL BRIQUETTE
CHARCOAL
WOOD PRESERVATIVE
BUTTONS
ASH TRAY
COCO SHELL (BAO NG NIYOG)
BUCKLE
UTENSIL
GLASS TRAY
HELMET
CAP
GUINIT
SPORT CLOGS
BEVERAGE (TUBA)
COCO WATER (TUBIG NG NIYOG)
VINEGAR
COIR DUST (PULBOS NG NIYOG)
PLASTIC BOARD
INSULATOR
WALL BOARD
JAM
GLYCERINE
COPRA
MEAT (LAMAN)
CRUDE OIL
BUTTER
SOAP
COCO MILK
OIL
LARD
HUSK (BUNOT)
COIR YARN
KITCHEN BRUSH
ROPE
COIR FIBER
BOTTLE BRUSH
DOORMAT
COIR RUG
ASBESTOS COIR TILE
COIR MAT
MEDICINE
BEVERAGE
DYE STUFF
ROOTS
TRUNK
FURNITURE
WOOD
PICTURE FRAME

DIAGRAMATICAL CHART OF A COCONUT TREE SHOWING THE DIFFERENT BY-PRODUCTS

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